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INTERNATIONAL TSUNAMI INFORMATION CENTER

Box 50027, Honolulu, Hawaii 96850-4993
Telephone: (808) 541-1658
TELEX: 984624 (ITIC UD)

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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
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INTERGOUVERNEMENTALE
COMISION OCEANOGRAFICA INTERGUBERNAMENTAL
МЕЖПРАВИТЕЛЬСТВЕННАЯ ОКЕАНОГРАФИЧЕСКАЯ КОМИССИЯ
اللجنة الدولية الحكومية لعلم المحيطات

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Box 50027, Honolulu, Hawaii 96850-4993
Telephone: (808) 541-1658
TELEX: 984624 (ITIC UD

Director: George Pararas-Carayannis

TSUNAMI NEWSLETTER is published by the International Tsunami Information Center to bring news and information to scientists, engineers, educators, community protection agencies and governments throughout the world.

We welcome contributions from our readers.

The International Tsunami Information Center (ITIC) is maintained by the U.S. National Oceanic and Atmospheric Administration (NOAA) for the Intergovernmental Oceanographic Commission (IOC). The center's mission is to mitigate the effects of tsunamis throughout the Pacific.

MEMBER STATES

Present membership of the IOC International Coordination Group for the Tsunami Warning System in the Pacific (ITSU) comprises the following States:

AUSTRALIA
CANADA
CHILE
CHINA
COLOMBIA
COOK ISLANDS
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA
ECUADOR
FIJI
FRANCE
GUATEMALA
INDONESIA
JAPAN
MEXICO
NEW ZEALAND
PERU
PHILIPPINES
REPUBLIC OF KOREA
SINGAPORE
THAILAND
UNITED KINGDOM (HONG KONG)
UNITED STATES OF AMERICA
UNION OF SOVIET SOCIALIST REPUBLICS
WESTERN SAMOA

TABLE OF CONTENTS

ANNOUNCEMENTS

PACIFIC TSUNAMI WARNING CENTER

FEATURE

THE EARTHQUAKES AND TSUNAMIS OF 17 & 30 NOVEMBER 1987

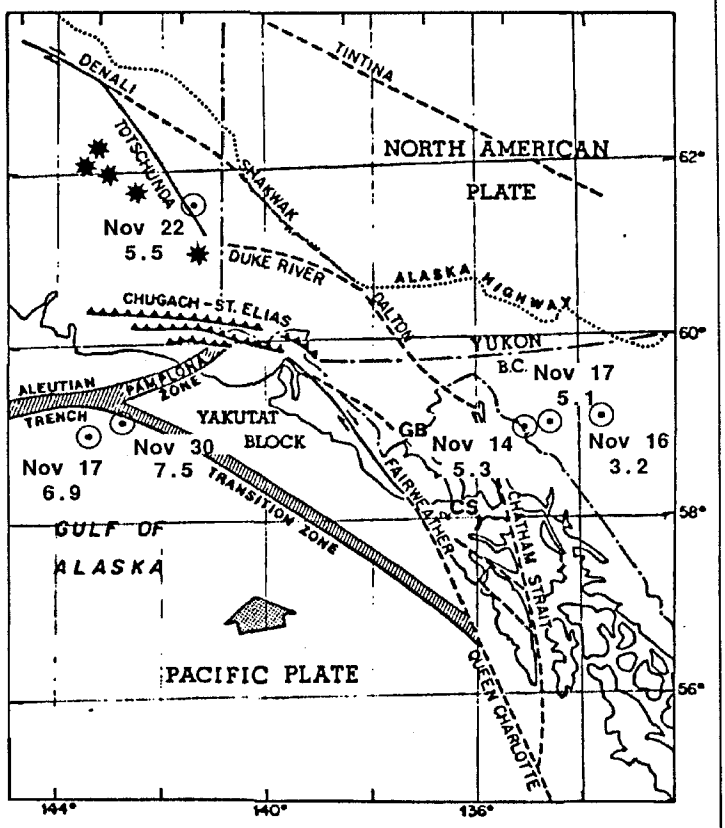
by George Pararas-Carayannis
Director,
International Tsunami Information Center

On 17 November 1987, at 0847Z (16 Nov. 1987 Alaska Standard Time), a strong earthquake of magnitude 6.9 occurred in the Gulf of Alaska. It was felt in Alaska and portions of British Columbia. The epicenter of the earthquake (shown in the figure) was at 59.0 North and 143.2 West, approximately 280 miles southeast of Anchorage and approximately 90 miles SW of Cape Yakataga. Within 11 minutes, the Alaska Tsunami Warning Center issued a regional Tsunami warning on the basis of seismic data. This warning covered the Alaska coastal area from Sand Point to Dixon Entrance, and British Columbia. A tsunami watch was issued for the remainder of Alaska and for the West Coast of the United States. A small Tsunami of less than 10cm registered at the Yakutat Tsunami gauge. No Tsunami registered at Seward or Sitka and the regional warning was cancelled shortly afterward. Location of the epicenter of the 30 November 1987 event in relation to the major tectonic elements is outlined in an illustration (Plafker 1978). Note location of epicenters and dates of other smaller earthquakes that occurred during the month of November 1987.

An earthquake measuring 7.5 on the Richter scale struck in the same general area in the vicinity of Cape Yakataga in eastern Alaska on Monday, 30 November 1987. The epicenter of this earthquake was in the Gulf of Alaska about 290 miles southeast of Anchorage at 59.3 North latitude, 142.5 West longitude. A small tsunami was generated with maximum height of 100cm recorded at Yakutat, and 20cm at Sitka, Alaska. The small tsunami was recorded in the Hawaiian Islands. The heights were 15cm at Hilo, 10-12cm in Nawiliwili, and 5-7cm in Honolulu. The Alaskan Tsunami Warning Center in Palmer, Alaska, issued a tsunami warning for Alaska and a tsunami watch for the West Coast of the U.S. and British Columbia. Both the warning and watch were subsequently cancelled. The Pacific Tsunami Warning System issued a tsunami watch for the Hawaiian Islands.

The earthquake of 30 November 1987 occurred on the western end of The Transition Zone that delineates the boundary between the Pacific Plate and The Yakutat Block. According to preliminary seismological information received, the orientation of the rupture was in a southwest northeast direction and it involved primarily normal faulting, rather than subduction faulting. This is probably the reason that the maximum tsunami recorded at Yakutat was only 100cm.

The Yakutat tectonic block, as illustrated in the figure, is bounded by The Pamploma zone which extends from the eastern end of the Aleutian Trench to the Chugach - St. Elias mountain region, by the Fair weather fault, and by the transition zone in the Gulf of Alaska. The region is capable of producing very large earthquakes and the area near Cape Yakataga represents a significant seismic gap where a large tsunamigenic earthquake can be expected in the future.



Major tectonic elements in Eastern Gulf of Alaska where the 17 and 30 November earthquakes occurred (map-Plafker, 1978).

NEWS EVENTS

XIX GENERAL ASSEMBLY OF THE IUGG

The IUGG General Assembly was held in Vancouver, Canada, in August 1987. A two-day Tsunami Symposium was held as part of the General Assembly, on 18-19 August. Thirty five papers were presented. Dr. Eddie Bernard, Pacific Marine Environmental Lab, NOAA, is arranging publication of the proceedings of the Tsunami papers.

TSUNAMI COMMISSION MEETS

There was a meeting of the IUGG Tsunami Commission on the afternoon of 18 August 1987. New commission officers were elected.

Chairman - Dr. Eddie Bernard, USA.
Vice Chairman - Dr. N. Shuto, Japan.
Vice Chairman - Dr. V. Gusiakov, USSR.
Secretary - Dr. G. Hebenstreit, USA.

Future Tsunami Symposia will be held in Novosibirsk, USSR, in August 1989; in Vienna, Austria, in August 1991 (in conjunction with the XX General Assembly of the IUGG); and tentatively in Shirahama Japan, in August 1993. Dr. Gusiakov made a presentation related to the 1989 meeting. The following members of the Tsunami Society presented the majority of the papers at the IUGG meeting in Vancouver, B.C., in August 1987 (no order):

Preuss, J. - Tsunami hazard reduction through risk mitigation.

Shuto, N. - Tsunami, oil spill, and fire.

Shuto, N. et al. - Numerical simulation of tsunami propagation and run-ups on historical tsunamis.

Soloviev, S. L. et al. - Experience of near-bottom currents recording with the help of pop-up containers.

Tsuji, Y. - Decay of the energy of the 1983 Japan Sea Tsunami.

Tsuji, Y. - Deaths of the 1707 and 1854 Tokai-Nankai earthquake-tsunami listed on necrologies of temples.

Takeda, A. and Y. Tsuji - Discrimination of tsunami flooded areas using satellite data.

Hebenstreit, G.T. and T.S. Murty - Preliminary studies of local tsunami hazards on the Washington-British Columbia coasts.

Murty, T.S. and Z. Kowalik - Future tsunamis in the Pacific Ocean.

Blackford, M.E. - Statistical relationships between earthquake momentum magnitude and water-level gauge heights for Pacific basin tsunamis.
Iwasaki, S. - On the estimation of a tsunami generated by a submarine landslide.

Hatori, T. - On the Aleutian tsunami of May 7, 1986, as observed along the coast of Japan.

Imamura, F., Goto, C. and N. Shuto - Numerical simulation of the Alaskan tsunami including the dispersion term.

Go, C.N. - Statistical properties of tsunami run-up on the coasts of the Kuril Islands and Japan.

Satake, K. and K. Shimazaki - Free oscillation of the Japan Sea excited by an earthquake.

Lander, J. and P.A. Lockridge - Impacts of tsunamis on the U.S. and associated territories.

Talandier, J., Reymond, D. and E.A. Okal - Mantle magnitude Mm: towards an automatic evaluation of the seismic moment and tsunami potential of a distant earthquake.

Pararas-Carayannis, G. - Source mechanism of volcanically generated tsunamis case study: the tsunami generated from the explosion and collapse of the volcano of Santorin in the Bronze Age.

Adams, W.M. and Zhou, Qinghai - Preliminary zonation of some populated coastal regions of China for tsunami hazard.

Koyama, J. - Focal mechanism of tsunami and tsunamigenic earthquakes.

Whitmore, P.M. and Sokolowski, T.J. - Rapid sizing of potentially tsunamigenic earthquakes at regional distances in Alaska.

Watanabe, H. - Tsunami occurrence and tectonics off the coast of Japan. Camfield, F.E. - Insufficient data effects on tsunami flood level predictions.

THE EARTHQUAKE OF 18 MARCH 1987

A strong earthquake of 6.8 on the Richter Scale, with epicenter at latitude 32.1 North and longitude 131.8 East, occurred off the East coast of the island of Kyushu, Japan about 120 miles south east of Nagasaki on March 18 1987, at 0336 UTC. No tsunami activity was reported to ITIC. PTWC issued an earthquake information bulletin.

THE EARTHQUAKE OF 17 JUNE 1987

An earthquake measuring 6.9 on the Richter scale, and with epicenter at latitude 14.0 South and longitude 167.8 East occurred at 0249 UTC about 1,300 miles north-east of Brisbane, Australia, followed by a 5.8 earthquake in the same general area. A small tsunami was triggered and authorities evacuated residents of low-lying areas of Vila, Vanuatu, but no casualties or damage were reported.

THE EARTHQUAKE OF 8 AUGUST 1987

An earthquake measuring 6.6 on the Richter Scale, with epicenter at latitude 18.6 South and longitude 69.3 West occurred at 1548 UTC in Northern Chile about 60 miles East of Africa. No tsunami activity was reported to ITIC. PTWC issued an earthquake information bulletin.

THE EARTHQUAKE OF 3 SEPTEMBER 1987

An earthquake measuring 7.1 on the Richter Scale, and with epicenter at latitude 59.4 South and longitude 157.9 East occurred at 0640 UTC about 1700 miles South of Melbourne, Australia. No tsunami activity was reported to ITIC. PTWC issued an earthquake information bulletin.

THE EARTHQUAKE OF 28 SEPTEMBER 1987

An earthquake measuring 7.0 on the Richter Scale, with epicenter at latitude 19.0 South and longitude 168.0 East occurred at 1147 UTC in the Vanuatu Islands about 1200 miles northeast of Brisbane, Australia. No tsunami activity was reported to ITIC. PTWC issued an earthquake information bulletin.

CALIFORNIA EARTHQUAKE OF 1 OCTOBER 1987

A strong earthquake measuring 6.1 on the Richter scale struck Southern California on 1 October 1987. The epicenter of the quake was about 9 miles South-southeast of Pasadena in the Montebello-South-Gate-Downey area at the North end of the Whittier-Elsinoze Fault. The earthquake was responsible for killing eight people, injuring dozens more, collapsing buildings, toppling walls, closing freeways, and touching off fires from broken gas lines. At least fifteen aftershocks followed in the same day. This was the strongest quake in the Los Angeles area since the Sylmar quake of 1971 in the San Fernando Valley northwest of Los Angeles which registered 6.4 on the Richter scale and was responsible for 64 deaths.

EARTHQUAKE AND TSUNAMI OF 6 OCTOBER 1987

An earthquake with magnitude 7.0 on the Richter scale occurred at 0419 UTC on 6 October 1987. Its epicenter was located at latitude 17.3 South, longitude 172.0 West at approximately 250 miles south of Apia, Western Samoa, in the Northern end of the Tonga Trench. Small tsunami waves of 25cm were recorded at Pago Pago, American Samoa, at 0510 UTC. No waves were recorded at Rarotonga, Cook Islands, and no other reports of the small tsunami were received. A general tsunami bulletin was issued by the Pacific Tsunami Warning Center.

THE EARTHQUAKE OF 12 OCTOBER 1987

An earthquake measuring 7.0 on the Richter scale and epicenter at 6.7 South latitude and 154.4 East longitude occurred at 1357 UTC on Monday, 12 October 1987, in the vicinity of the Solomon Sea near Papua-New Guinea and about 1450 miles North of Brisbane, Australia. No report of tsunami activity was received by ITIC. The Pacific Tsunami Warning Center issued an earthquake information bulletin.

THE EARTHQUAKE OF 16 OCTOBER 1987

An earthquake recorded by the Pacific Tsunami Warning Center occurred at 2048 UTC on 16 October in the vicinity of South New Britain, Papua-New Guinea. The earthquake measured 7.7 on the Richter scale and had its epicenter at 6.3 South latitude, 148.5 East longitude. No report of tsunami activity has been received at ITIC. The Pacific Tsunami Information Center issued an earthquake information bulletin.

THE EARTHQUAKE OF 25 OCTOBER 1987

A strong earthquake occurred in West Irian, Indonesia, at latitude 2.2 South, longitude 138.9 East, about 125 miles west of Jayapura at 1654 UTC on 25 October 1987. The magnitude was computed at 6.9 on the Richter scale. No reports of tsunami activity were received at ITIC. The Pacific Tsunami Warning Center issued an earthquake information bulletin.

EARTHQUAKE OF 25 OCTOBER 1987

An earthquake measuring 4.0 on the Richter scale jolted Southern California at 4:59 pm on 25 October 1987, and was centered in the Pacific Ocean near Santa Barbara Island, 60 miles southwest of downtown Los Angeles. No damage or injuries were reported. The quake was not an aftershock of the magnitude 6.1 earthquake near Whittier, of October 1, that killed 8 people and caused more than $177 million in damage. The quake rattled homes along nearly 100 miles of coastline from San Clemente in Southern Orange County, to Malibu and was felt as far inland as San Bernardino.

VOLCANO ERUPTS IN JAPAN

On 16 November 1987 Mount Mihaza on Oshima Island in Japan erupted. The eruption came a year and a day after a much larger eruption that forced the evacuation of residents of Oshima Island for about a month. Residents on the island were told that the present eruption does not present an immediate danger and that there is no need to evacuate.

SOUTHERN JAPAN SHAKEN BY EARTHQUAKE, 18 NOVEMBER 1987

An earthquake measuring 5.5 on the Richter scale shook parts of southern Japan early on Wednesday 18 November 1987, injuring three people. The Central Meteorological Agency said that the epicenter of the earthquake was in the northern Yamaguchi Prefecture on the extreme southwestern tip of the Japanese main island of Honshu.

THE EARTHQUAKE OF 26 NOVEMBER 1987, IN INDONESIA

According to the Associated Press, an earthquake with epicenter in the Flores Sea and measuring 5.8 on the Richter scale rocked the island of Pantar in Indonesia, and was responsible for numerous deaths and destruction. According to the Associated Press, the quake also caused a huge tsunami that swept onto the island. The same article also states that 50 homes were destroyed and 12,000

people in six villages were cut off from the rest of the island. However, the article does not make it clear whether it was the tsunami or the earthquake that was responsible for the deaths or the damage. ITIC has not received any reports of a tsunami from this particular earthquake. Letters have been sent out to Indonesian authorities requesting clarification and confirmation of a tsunami. Usually earthquakes of magnitude less than 6 on the Richter scale do not produce significant tsunamis. ITIC will publish in its next newsletter any information it receives on this particular event.

INTERNATIONAL TSUNAMI INFORMATION CENTER

ITIC Progress Report 1985-1987

The Director of ITIC, Dr. George Pararas-Carayannis completed a biannual progress report of The International Information Center (ITIC) for 1985 – 1987. This report was presented at XI Session of the ICG/ITSU Meeting in Beijing – China in September this year. Copies were distributed to all ITSU Member Countries. A limited number of copies is available by writing to:

ITIC
P.O. Box J0027
Honolulu, HI 96850, USA

Visiting Scientists Program - 1987

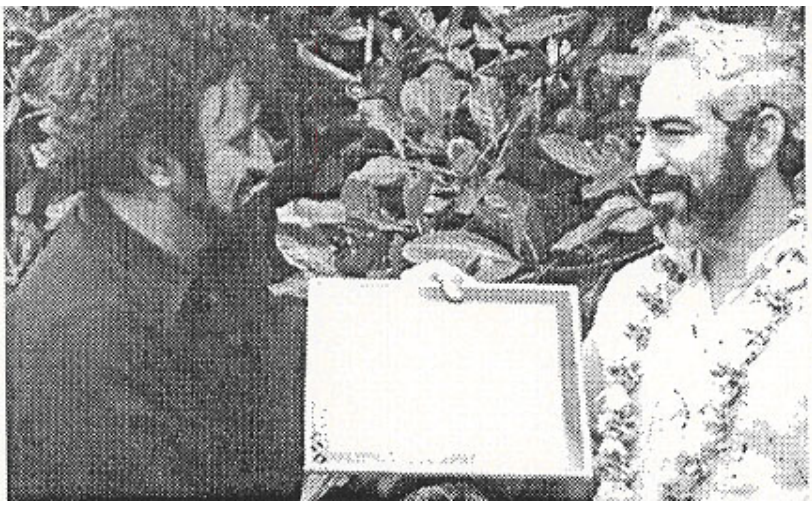
Lieutenant Miguel Pin-Nieto of Peru and Mr. Jorge Zea-Mazo of Colombia were the two visiting scientists who completed in 1987 a 6-week training course at the International Tsunami Information Center (ITIC), in Honolulu. The training program is sponsored and funded by the Intergovernmental Oceanographic Commission (IOC).

Lieutenant Pin-Nieto is a naval officer with the Hydrographic Institute of the Peruvian Navy and Chief of the Physical Oceanography Division which is responsible for tsunami studies, the tsunami tide gauges, and operations related to the Tsunami Warning System.

Mr. Zea-Mazo is a scientist with the Colombian Institute of Hydrology, Meterology and Oceanography (HIMAT), which is responsible for the operations of the tsunami tide gauges and communications of the warning system in Colombia.

The training these visiting scietists received was comprehensive and took place in Hawaii from October 25 to December 4, 1987. The scientists were thoroughly familiarized with the operations of the Tsunami Warning System, and had a thorough introducetion on all aspects of the tsunami problem. In addition, they worked on specific problems related to tsunami warning in their own country and on improvements of communications. Final reports by the visiting scientists were prepared and submitted to the IOC Secretariat.

Mr. Zea-Mazo also worked on a



Mr. Miguel Pin-Nieto of Lima, Peru (above) and Mr. Jorge A. Zea-Mazo of Bogota, Colombia (right) receive their certificates of completion of training from Dr. George Pararas- Carayannis, Director of ITIC.

proposal for a Regional Tsunami Warning System for Colombia, which will require the installation of several automated tide and seismic platforms integrated with a Civil Defense infrastructure of the country. Lt. Pin-Nieto completed a similar study. Both Colombia and Peru have been greatly affected by destructive tsunamis in the past few years and such planning is required.

Overall, the training was a rewarding experience for the scientists and for the rest of the ITIC and PTWC staff that worked with them. The training these scientists received and the exchange of ideas, have already resulted in positive benefits to the Tsunami Warning System and enhanced the working ties and spirit of cooperation among the ITSU member countries.

ICG/ITSU

Eleventh Session of the International Coordination Group for the Tsunami Warning System in the Pacific Beijing, China, 8-12 September 1987

The Eleventh Session of the International Coordination group for the Tsunami Warning System in the Pacific (ICG/ITSU) met in Beijing, China, 8-12 September 1987. The meeting was hosted by the State Oceanic Administration of the People's Republic of China.

The following is a summary of the provisional Agenda of the meeting:

1. ORGANIZATION OF THE SESSION

2. INTERSESSIONAL ACTIVITIES

3. IMPLEMENTATION OF RESOLUTIONS AND RECOMMENDATIONS OF THE TENTH SESSION OF THE ICG/ITSU (1-3 AUGUST 1985, SIDNEY, CANADA)

   3.1 Master Plan for International Tsunami Warning System

   3.2 Tsunami Travel- Time Charts

   3.3 Glossary of Tsunami Related Terms

   3.4 Data Base Format

   3.5 Communication Plan

4. OPERATIONAL IMPROVEMENTS TO THE TSUNAMI SYSTEM

5. COOPERATION WITH IUGG TSUNAMI COMMISSION AND OTHER INTERNATIONAL BODIES INVOLVED IN TSUNAMI MITIGATION AND RESEARCH

6. TRAINING AND ASSISTANCE IN TSUNAMI PREPAREDNESS

7. MANDATE AND FUNCTIONS OF THE INTERNATIONAL TSUNAMI INFORMATION CENTER

8. PLANS FOR THE FUTURE

9. OTHER BUSINESS

10. DATE AND PLACE OF THE NEXT SESSION

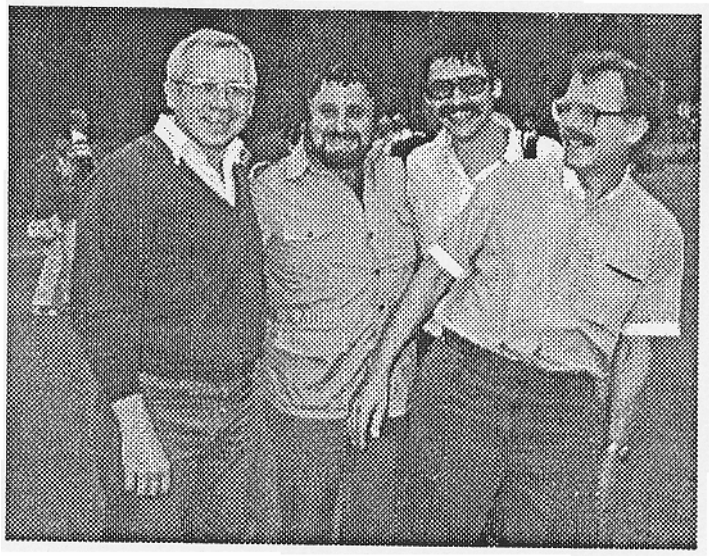
11. ELECTION OF THE CHAIRMAN AND VICE-CHAIRMAN

12. ADOPTION OF THE SUMMARY REPORT AND RECOMMENDATIONS

Participants to the Xl Session of the International Coordination Group for the Tsunami Warning System in the Pacific, ICG -- ITSU, pose for a group picture near the Great Wall of China during a short excursion following the Conference in Beijing. (The reason everyone is smiling is because they had not as yet started their climb of the Great Wall.)

13. CLOSURE

A summary report of the Eleventh Session has been prepared and will be distributed in the very near future by the Secretariat of the Intergovernmental Oceanographic Commission (IOC). Because of the voluminous nature, the national reports presented at the Eleventh Session are not included in the summary report but are included in the present Tsunami Newsletter under the section "Area and National Reports."



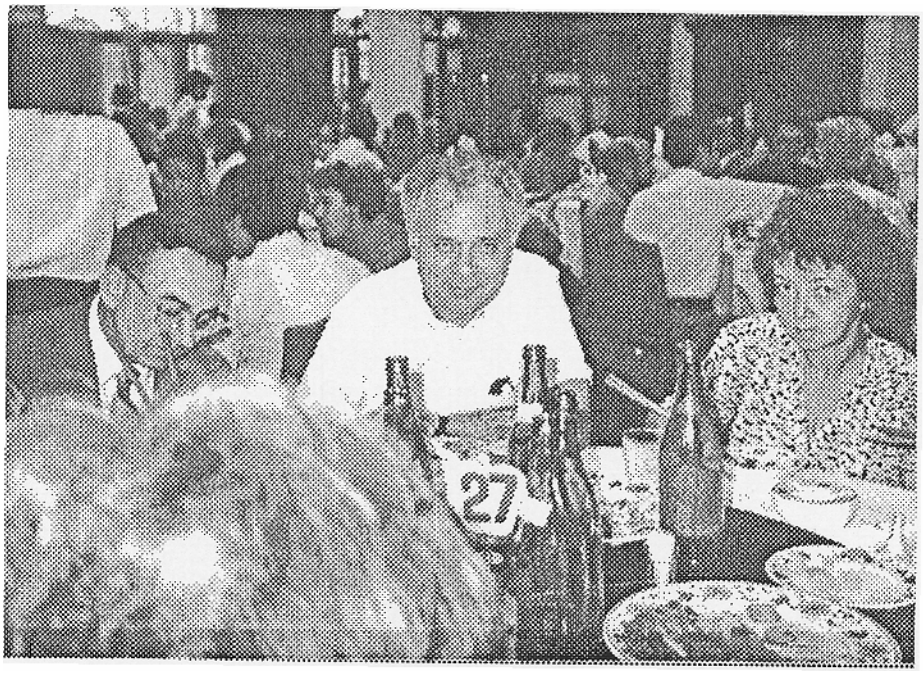
A few candid and informal photographs of participants to the ITSU XI Conference.

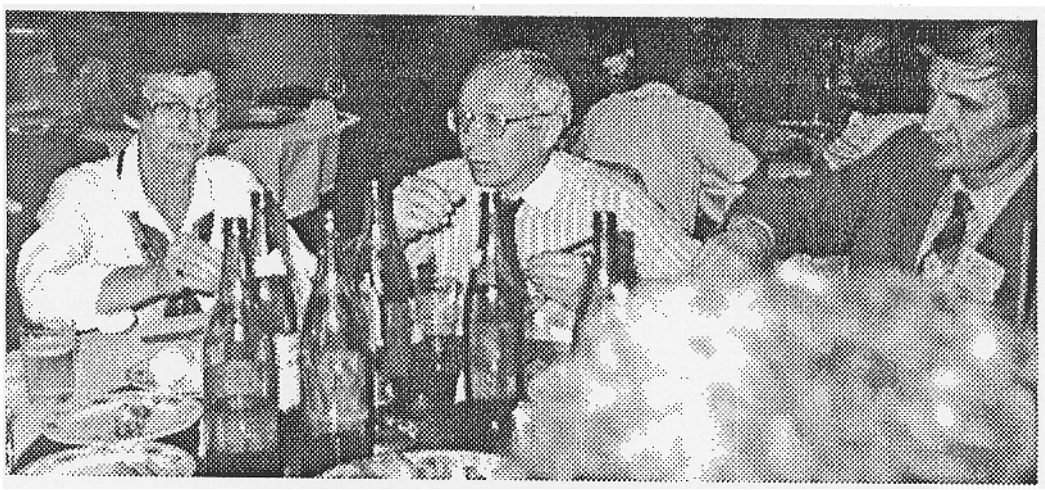
(top left) While all the delegates were working hard at the Conference, their spouses were out spending their money, having fun, and visiting neat places like the forbidden city (Ed. lt just wasn't fair).

(above) During an excursion following the ITSU meeting in Beijing, Mr. Tom Sokolowski, Director of the Alaska Tsunami Warning Center climbed to vantage point near the Great Wall of China to be the first to photograph a tsunami striking the Great Wall. (Ed. Last we heard Mr. Sokolowski was still in China, at his vantage point, waiting).

(above) Dr. I. Oliounine (IOC), Dr. G. Pararas-Carayannis (ITIC), Dr. V. Berdin, and Dr. Y. Shokin (USSR) pose for an informal photograph during a tour after the meeting. (Ed. The reason everyone is smiling is because they have not yet started their climb of the Great Wall)

(right) Mr. Tom Sokolowski (USA), Professor S. Soloviev (USSR) and Mrs. Marlene Sokolowski posing for a candid photograph between servings of beef broccoli and sweet-sour shrimp.

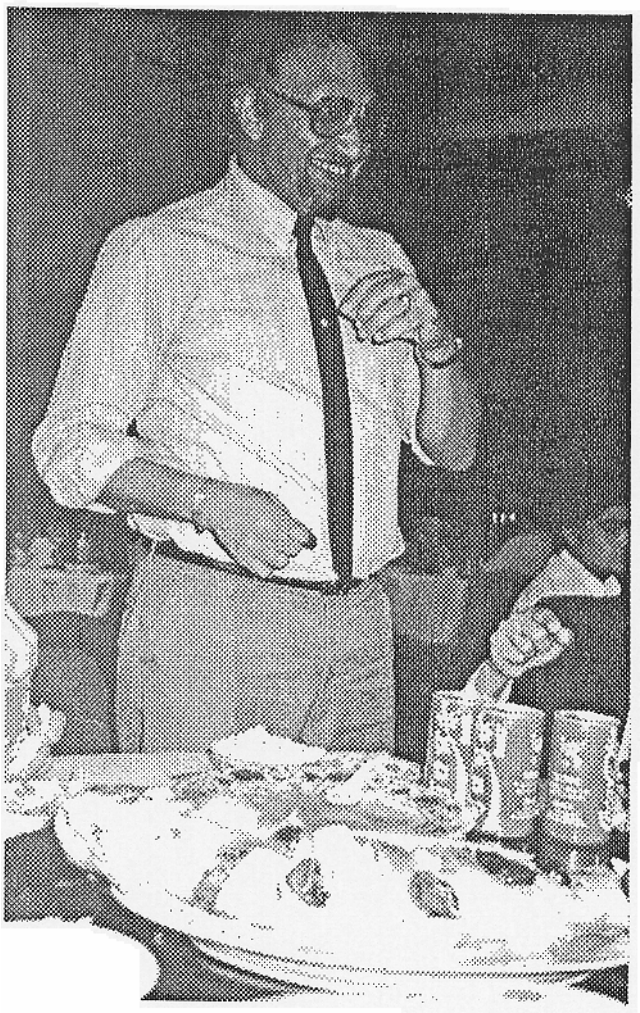


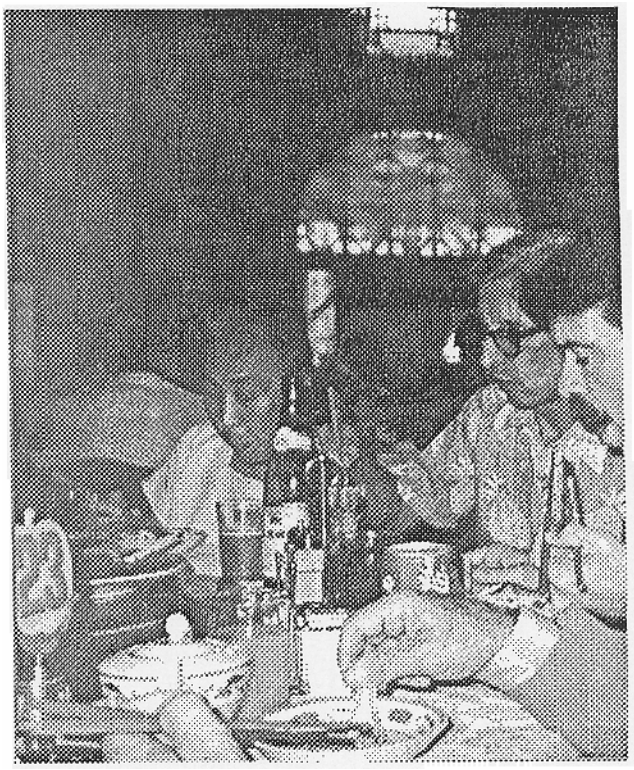


(left) Dr. Iouri Oliounine caught by the camera in a spontaneous pose with Mr. and Mrs. Rapatz and Dr. Guisakov during a lunch recess. (Ed. Later Dr. Oliounine issued a disclaimer stating that the empty beer bottles in front of him were already on the table when he got there.)

(below) Mr. G. Dohler, past chairman of ICG/ITSU poses for a photograph during lunch recess with Mrs. Marlene Sokolowski and Ms. Mirelle Larche. (Ed. This was the table with the most empty beer bottles.)

(bottom) During an excursion following the ITSU Conference in Beijing, Dr. George Pararas-Carayannis tried to persuade Professor Mohamed El Sabh, of the Canadian Delegation, of the existence of progressive long waves of the elementary type in a boundless layer of viscous fluid of constant depth rotating with angular velocities below the Coriolis parameter. Professor El Sabh stood firm and refused to accept the existence of such waves.



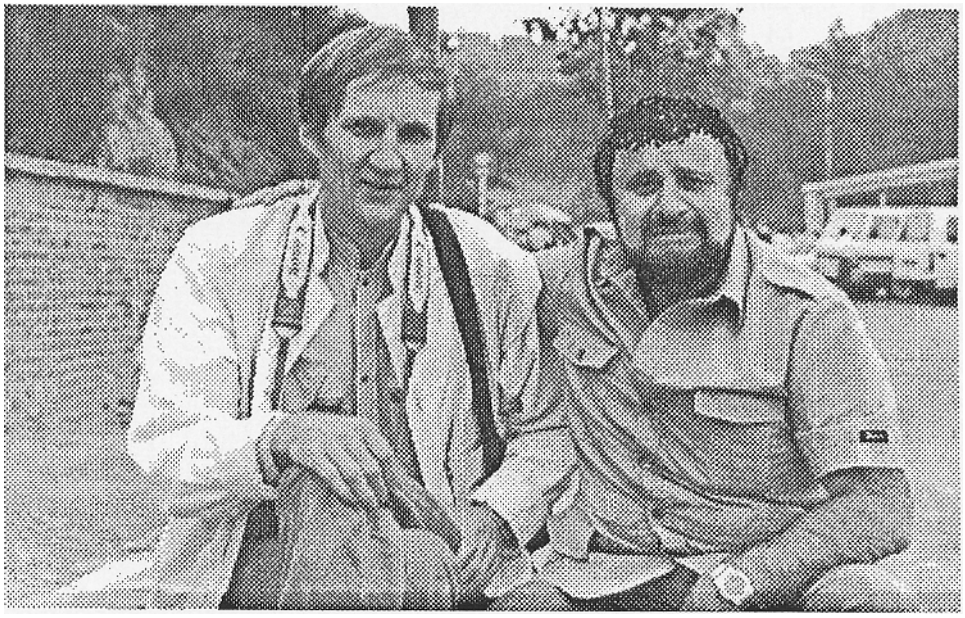


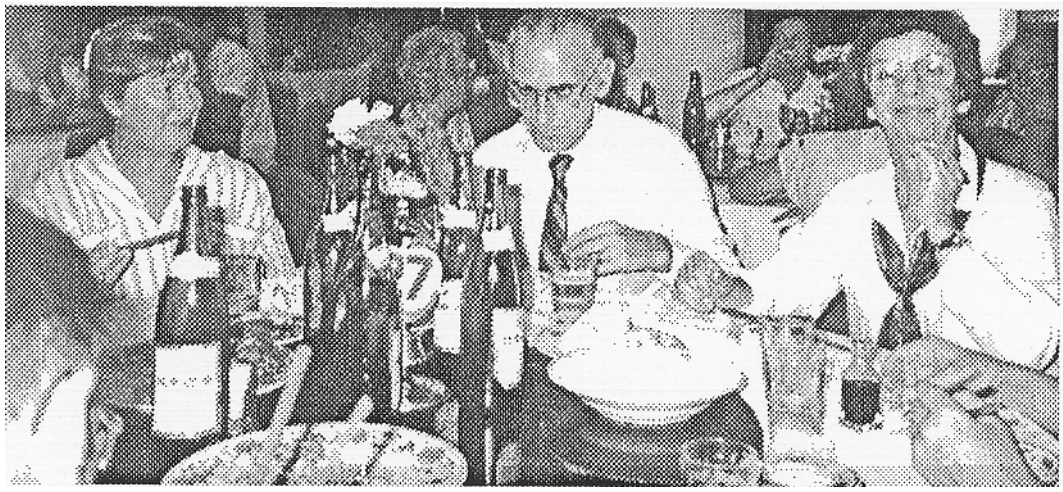
(top left) Professor Mohammed El Sabh (Canada) posing in front of a big fish moments before it was devoured (Ed. Please note that everyone at this table, including myself, are drinking Chinese Coca-Cola, and not beer).

(top right) Mr. and Mrs. R. Hagemeyer (USA) and DR. Y. Kilonsky (USA) wondering what happened to the big fish that was on the table a few seconds before.

(bottom) Commander H. Soldi (left) of the Peruvian delegation, and Professor M. El Sabh and Dr. T. Murty of the Canadian delegation during lunch recess. (Ed. Later, both Dr. Murty and Commander Soldi commented, and we quote "We did not have a chance to eat anything ." We really don't know what happened to the fish.)

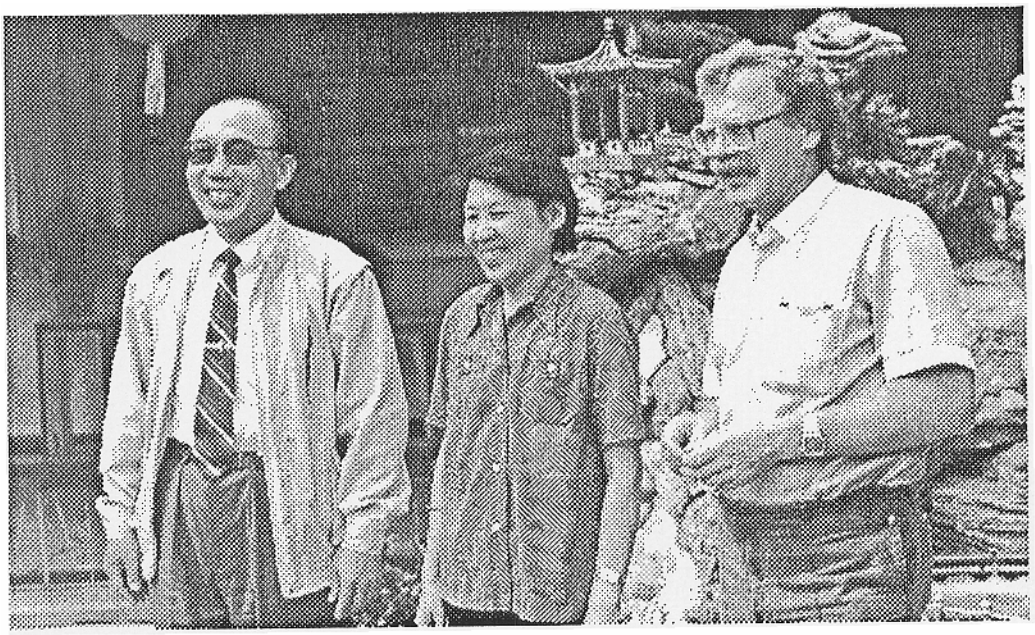
Dr. S. Gusiakov (USSR) did not believe Dr. Pararas-Carayannis's story about the existence of these progressive waves either. But he did listen politely.





(left) Mr. W. Rapatz (Canada) with his lovely wife and Ms. Mirelle Larche. (Ed. This table tied for first place in the empty beer bottle contest.)

Dr. and Mrs. Yang Huating, People's Republic of China, were the hosts of the ITSU meeting. Professor I. Shokimi, of the USSR, in front of a restaurant during an excursion following the ITSU meeting. (Ed. The hosts asked, politely, Dr. Pararas-Carayannis to get off the horse before entering the restaurant, which he did.)



National Contacts

Australia
Mr. P.F. Noar
Assistant Director (Services)
Bureau of Meteorology
GPO Box 1289 K
Melbourne, Victoria 3001
Australia

Canada
Mr. W. J. Rapatz
Regional Tidal Superintendent
Institute of Ocean Sciences
Dept. of Fisheries and Oceans
P.O. Box 6000
Sidney, B.C. V8L 4B2, Canada

Chile
Captain Carlos Bari White
Director
Instituto Hidrografico de la Armada
Casilla 324
Valparaiso, Chile

China
Mr. Luo Yuru
Director
National Bureau of Oceanography
of the People's Republic of China
Beijing, China

Colombia
Commander Ricardo Alvarado
Secretario General
Comision Colombiana de
Oceanografia
Apartado Aereo No. 28466
Bogota, D.E., Colombia

Cook Islands
Commissioner H. R. Melrose
Police National Headquarters
P.O. Box 101
Rarotonga, Cook Islands

Ecuador
Calm. Fernando Alfaro Echeverria
Director
Instituto Oceanografico de la
Armada
Cailla 5940
Guayaquil, Ecuador

Fiji
Mr. A. Rahiman
Director, Mineral Development
Mineral REsources Department
Private Mail Bag
Suva, Fiji

France
Dr. M. Jacques Recy
Directeur de la Recherche
Office de la Recherche Scientifique
et Technique Outre-Mer
B.P. A5
Noumea Cedex (Nouvelle Caledonie)
France

Guatemala
Ing. Eddy Hardie Sanchez Benett
Instituto Nacional de Sismologia
Vulcanologia, Meteorologia e
Hidrologia
Ministerio de Comunicaciones
Transporte y Obras Publicas
7a Avenida 14-57 Zona 13
Guatemala, C.A.

Indonesia
Dr. Aprilani Soegiarto
Center for Research and
Development in Oceanology
Kompleks Bina Samudera
P.O. Box 580 Dak
Jakarta, Indonesia

Japan
Dr. Mamoru Katsumata
Head, Earthquake and Tsunami
Observation Division
Japan Meteorological Agency
1-3-4, Ote-machi, Chiyoda-ku
Tokyo, Japan 100

Korea
(DPR of Korea)
Mr. Jong Young Gu
National Oceanographic
Commission
Hydrometeorological Service
P.O. Box 100
Pyongyang
Democratic People's Republic of
Korea

Korea (Republic of)	Mr. Sang-jo Kim Assistant Director Observation Division Weather Forecast Bureau Korean Meteorological Service 1 Songwol-dong, Chongno-gu Seoul 110, Korea
Mexico	Lic. Ma de los Angeles Lopez-Ortega Ministro Consejero Encargada de Negocios a.i. UNESCO Delegacion Permanente de Mexico 1, Rue Miollis 75732 Paris, France
New Zealand	Dr. Alex E. Gilmour Dept. of Scientific & Industrial Research New Zealand Oceanographic Institute Private Bag Kilbirnie Wellington, New Zealand
Peru	Contralmirante Jorge A. del Aguila Sanchez Direccion de Hidrografia y Navegacion de la Marina Casilla Postal No. 80 Gamarra No. 500 Chucuito, Callao, Peru
Philippines	Mr. Conrado M. Santos Chief Geophysicist Physical Science Division Bureau of Coast & Geodetic Survey 421 Barraca St. San Nicolas, Manila, Philippines
Singapore	Mr. Paul Lo Su Siew Director Meteorological Service Singapore P.O. Box 8 Singapore Changi Airport Singapore 9181, Republic of Singapore
Thailand	Commander Thanom Charoenlaph Hydrographic Department Royal Thai Navy Bangkok 6, Thailand
United Kingdom (Hong Kong)	Mr. Patrick P. Sham Royal Observatory, Hong Kong 134A Nathan Road Kowloon, Hong Kong
USA	Mr. Richard H. Hagemeyer Director National Weather Service, Pacific Region Box 50027 Honolulu, Hawaii 96850-4993 USA
USSR	Dr. B.P. Khimitch Chief, Arctic and Antarctic Department USSR State Committee for Hydrometeorology and Natural Environmental Control 12, Pavlik Morozov Per. Moscow 123376 USSR
Western Samoa	The Superintendent Apia Observatory P.O. Box 3020 Apia, Western Samoa
Director, ITIC	Dr. George Pararas-Carayannis Director International Tsunami Information Center Box 50027 Honolulu, Hawaii 96850-4993 USA TELEX: 984624 (ITIC UD)
Chairman, ICG/ITSU	Mr. Richard H. Hagemeyer Director National Weather Service, Pacific Region Box 50027 Honolulu, Hawaii 96850-4993 USA

NATIONAL AND AREA REPORTS

The following National Reports were submitted at the XII Session of the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU), in Beijing, China which was held on September 8-12, 1987.

ITIC has been asked by the International Oceanographic Commission (IOC) to include these reports in the Tsunami Newsletter so that the publication of the Summary Report of the XII Session of ICG/ITSU will not be delayed. These reports are presented here in their entirety.

NATIONAL REPORT OF AUSTRALIA

Since 1961,the Bureau of Meteorology has been involved in the dissemination of warnings from the Pacific Tsunami Warning Center (PTWC) in Honolulu to users within Australia and the neighboring areas such as Lord Howe and the Norfolk Islands, the Cocos Islands, Christmas Island, the Solomon Islands, Nauru and Papua-New Guinea. In 1986, Australia joined the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU).

TSUNAMI RISK IN AUSTRALIA: Australia is fortunate to have a comparatively low exposure to tsunami effects, both from the major seismic wave source areas in the Pacific and to the North. Although no formal study of tsunami risk to Australia has been undertaken yet, it is presumed to be negligible, except for seismic events originated in some parts of Indonesia, or New Zealand from where tsunamis would reach the southeast coast of Australia within 2 to 3 hours.

The Australian Seismological Center of the Bureau of Mineral Resources, is undertaking a tsunami risk assessment for Australia, based on the examination of historical data. This study is expected to be completed by 1989.

TIDAL DATA: The network of tide gauges in Australia consists of over 100 tide gauges owned by various organizations. A representative subset of these have been used to form a national network with overall coordination by the Permanent Committee on Tides and Mean Sea Level, which comprises representatives from national agencies and institutions (including the Bureau of Meteorology). The Committee has been instrumental in improving the standard of observations from these gauges and has plans for installation of gauges at additional sites. The quality of the data from several gauges is limited due to the age of the instrumentation and the remoteness of their sites which make maintenance very expensive.

After an event, retrieval of the analogue chart may take from one to several days, depending on the remoteness of the gauge. Processing and data base maintenance is carried out by Prof. G.W. Lennon at the Flinders Institute of Atmospheric and Marine Sciences (FIAMS) near Adelina, South Australia.

The Bureau has real-time access to a telemetered tide gauge at West Inner Bar Beacon, Brisbane, and 20 recorders along the Queensland coast operated by the Beach Protection Authority which can be interrogated by telephone. However, these gauges are all protected by the Great Barrier Reef.

TSUNAMI RESEARCH: Some current Tsunami research in Australia includes computation of travel time charts using computer based mathematical models of wave dynamics. This work is being progressed by Dr. R. Braddock at Grifith University, Queensland. Work on estimating the Tsunami-causing seismic disturbance, from tidal gauge analysis, will soon be reported in a paper "Estimating Tsunami Generating Regions" by P. Doiliby and R. Braddock.

The modeling of wave run-up and other shore effects, including resonant effects in harbors, is being undertaken by Prof. Noye of the University of Adelaide.

NATIONAL DISSEMINATION OF TSUNAMI WARNINGS: Warning from Tsunami Warning Centers are received at the Australian Naval Communications Base 'HMAS Harman', and are then disseminated to the New Zealand Defense Forces, the Australian National Defense Forces, the National Disasters Organization (NDO), and the Coastal Surveillance Center (CSC) in Canberra, and the Head Office of the Bureau of Meteorology in Melbourne. From there, they are disseminated to the Bureau's Regional Offices in each state where the warnings are interpreted and advice is given to designated local civil defense, police and other concerned organizations.

The issuing of dummy Tsunami warnings has proved useful in maintaining the efficiency of the system and identifying operational problems. As a result, the Bureau plans to provide staff in Regional Offices with a Tsunami Information Resource Manual, including travel time charts, to enable adequate interpretation of warnings.

NATIONAL REPORT OF CANADA

INTERNATIONAL TSUNAMI WARNING SYSTEM: During 1985, 1986 and part of 1987, Canada maintained 3 tide stations in the International Tsunami Warning System, at Tofino, Bamfield and Langara Island. Due to technical difficulties and the age of the recording equipment, the gauge at Tofino was officially removed from the list of Tsunami gauges on 27 July 1987. Bamfield and Langara gauges are accessible by telephone on a 24-hour basis.

Within the next 2 years, it is planned to replace the tsunami gauge at Langara with a gauge in Rennell Sound on the West coast of Graham Island in the Queen Charlotte Islands Group. Canada also plans to add another Tsunami gauge at Winter Harbour near the Northern tip of Vancouver Island.

In recent years, Canada has been experimenting with data transmission from tide gauges by means of the Meteor Burst System. Two tidal stations are already equipped with Meteor Burst. It is planned that data transmission from the proposed gauges at Rennell Sound and Winter Harbour will be by means of this system.

TRAINING AND EDUCATION: We have been carrying out a planned schedule of education of the public with regard to Tsunami emergencies and Tsunami damage mitigation. The Province of British Columbia has commissioned the making of a short educational video film explaining the nature of Tsunamis and what to do in case of an emergency. With this film and other educational material supplied by the Provincial Emergency Program of the Province of British Columbia, speakers have been sent to outlying communities on the coast to speak to community groups, schools and officials responsible for emergency planning. As another means of informing the general public, the Federal and Provincial Governments are also cooperating with universities in the organization of symposia on earthquakes and Tsunamis.

INTERNATIONAL MEETINGS: Canada hosted an International Symposium on Natural and Man-made Hazards, which was held at the University of Rimouski, in the Province of Quebec, in August 1986. This symposium was well attended and served as a forum for experts in the Tsunami field. A number of subjects significant to the Tsunami Warning System were discussed.

In August 1987, Canada hosted the XIX General Assembly of the International Union of Geodesy and Geophysics (IUGG). Over 3,800 participants were registered. The chairman of the Tsunami Commission of IUGG was Dr. T.S. Murty of Canada. A Tsunami Symposium was held during the Congress and many papers were presented on this subject.

MASTER PLAN FOR THE TSUNAMI WARNING SYSTEM: Mr. G.C. Dohler of Canada, past chairman of ITSU, has prepared a Master Plan for the Tsunami Warning System in the Pacific on behalf of ITSU and has submitted a revised version of this plan to the International Oceanographic Commission. Canada believes this plan to be an important document and recommends its approval at the Eleventh Session of ITSU.

In order to improve the warning procedures and decision-making in the event of a major Tsunami in the Pacific, the Federal Government of Canada has placed a contract with Seaconsult Marine Ltd. of Vancouver to compute probable Tsunami amplitudes and travel times at about 80 locations on the coast of British Columbia. Tsunami propagation in the deep ocean is numerically simulated using Boussineq equations in polar spherical coordinates. Propagation over the continental shelf is simulated using shallow water equations. Propagation into the inlets and estuaries is computed using some 40 different one-dimensional models. The models are calibrated against historical data. The final report on this study will be available in October of 1987.

NATIONAL REPORT OF CHINA

1. INTRODUCTION

The integrated warning system of Tsunami and storm surges in China is operated and coordinated by the State Oceanic Administration, as part of the National Services System. Tsunami research is conducted not only by the State Oceanic Administration but also by other research institutions. The analysis and forecast Center of the National Bureau of Seismology is in charge of seismic data supply and is engaged in ocean floor earthquake research. The Tsunami hazard prevention program is performed by Flood Control agencies at both levels of provinces and state, and the telecommunication program is assisted by the Ministry of Telecommunication and State Meteorological Administration (through GTS).

2. INTERSESSIONAL ACTIVITIES

A. Tidal Gauge Stations: Owing to the implementation of the program of the Coastal Telecommunication Network for Tidal Stations, field data from 54 coastal tide

and oceanic stations run by the State Oceanic Administration can be directly transmitted to all of those branches of the State Oceanic Administration from 1 July 1986. Then, data will be transferred to the National Research Center for Marine Environmental Forecast at Beijing. From those branches, 20 stations out of 54 can supply tide data. However, the entire automatic transmission for the foregoing data supply procedure cannot be implemented until the end of 1988 when all of the computers at NRCMEF and at those branches are put into operation. Besides, the State Oceanic Administration is right now coordinating with the Ministry of Water and Electricity, the Ministry of Transportation and other institutions, in order to link all the oceanic stations together. Very soon, one nation-wide network of tide observations, out of which at least 50 stations will be able to transmit real-time data on a scheduled basis.

The State Oceanic Administration has supplied data from 6 oceanic stations to ISLPP of IGOSS and will endeavor to perform the implementation plan of 1985-1990 (IOC/INF-663 rev.) for GLOSS.

B. Establishment of Archival for Tidal Data: Conventional and computerized technology is used at the National Oceanographic Data Center at Tianjin for the filings and quality control of historical tidal data, so as to make it easier for the research work of Tsunami and storm surge hazards and other purposes.

C. Tsunami Research: It is important to study the history of Tsunami and storm surge events based on historical data. During the period of 1985 to 1987, some research work has been carried out by Mr. H.T. Yang and Q.H. Zhou. They believe that, because China has a broad continental shelf, distant tsunami will have an insignificant effect, but small local Tsunamis will be frequent with a frequency of generation approximately every 21 years. However, a catastrophic Tsunami was generated in the year 1871 and about 50,000 lives were lost.

Mr. Q.H. Zhou had finished a paper on the Tsunami Data Base for China (co-authored with W.M. Adams) and presented it at the Meeting of the Pacific Congress on Marine Science and Technology, on 24-28 March 1986 in Honolulu, Hawaii. Mr. Zhou has also finished the papers on Tsunami Risk Analysis for China, and on the Coastal Response of Tsunami Waves and Preliminary Zonation for Tsunami Hazards in China (co-authored with W.M. Adams).

D. Experts Visiting: According to the Bilateral Agreement of China and the USA, Mr. H.T. Yang and Q.H. Zhou were sent to ATWC (at Palmer, Alaska), PTWC and ITIC (at Honolulu, Hawaii) for the Tsunami Program Visiting Study in August 1985. In the meantime, the delegation of Tsunami from the USA, headed by Dr. Walter Dudley, visited the State Oceanic Administration of China, in May 1987, and inspected some of the tide stations and instruments deployed for the oceanic service system. At the same time, scientists from both countries have been exchanging ideas and discussing related matters for the warning operations on Tsunami hazards.

E. Establishment of the China Research Society of Storm Surges and Tsunamis: China is frequently struck by storm surges and there are as many as over 100 experts working on this problem who are members of the China Research Society of Storm Surges and Tsunamis, under the guidance of the China Society of Oceanography and the China Society of Oceanology and Limnology. In order to accelerate the development of research and warning operations for storm surges and Tsunamis, the name of the China Research Society of Storm Surges was changed into the China Research Society of Storm Surges and Tsunamis (CRSSST), in the Second Congress of the CRSSST with a total number of 170 members.

F. Preparation for the ITSU-XI and Storm Surge Symposium in Beijing, September 1987: Preparations have been made by the State Oceanic Administration to host the meeting of IOC/ITSU-XI and the Storm Surge Symposium. For the sake of promoting technical communication between scientists of China and foreign countries, one proposal has been put forward for the International Symposium of Storm Surges to be held at the same time and place as IOC/ITSU-XI, sponsored by the State Oceanic Administration, the Intergovernmental Oceanographic Commission, the China Research Society of Storm Surges and Tsunamis, and the China Society of Oceanology and Limnology, and others.

NATIONAL REPORT OF CHILE

1. INTRODUCTION:

This report sums up Chile's activities in the operation and maintenance of the National Tsunami Warning System during the Period of May 1985 - April 1987.

2. ACTIVITIES CONDUCTED DURING THE PERIOD:

2.1 Improved instrumentation: In view of the many operational problems posed by the old Ballauf automatic tide gauge, it was replaced at several tide stations by the

Metercraft Gas tide gauge, sometimes at a new site. The stations where such replacements were made are:

	New Location	
Iquique	20 12' 08" S.	70 08' 41" W.
Talcahuano	36 42' 33" S.	73 06' 32" W.
Antofagasta	not registered.	

2.2 Participation in the TOGA Program: As announced at the ninth session of ICT/ITSU, several tidal-data collecting platforms have been installed in Chile. Their locations are as follows: Arica, Caldera, Valparaiso and the Isle of Pascua. (The one on St. Felix Island is due to be installed in 1987). These platforms transmit their data to the GOES satellite.

2.3 Participation in the THRUST (Tsunami Hazard Reduction Using System Technology) project: The Naval Hydrographic Institute, in conjunction with the Regional Emergency Office of the Valparaiso region, has prepared an operational handbook for the Tsunami early warning system that includes evacuation procedures for the cities of Valparaiso and Vina del Mar ; this is available from Chile's Hydrographic office). Preparation of the handbook began with the cooperation of ITIC when Chile participated in the visiting experts training program in August 1984. Project instrumentation was installed by technicians of NOAA's Pacific Marine Environmental Laboratory in mid-1986 and it is operating without problems during the testing stage.

2.4 Activation of the National Tsunami Warning System: Various seismic events occurring during the period between meetings activated the National Tsunami Warning System. The main ones are listed in TABLE 1.

3. FUTURE ACTIVITIES

3.1 THRUST project: At the end of the THRUST project, and prior to the phase during which the functioning of the equipment will be evaluated, a meeting will be organized in Chile. This meeting is tentatively scheduled for the beginning of 1988, to provide ICG/ITSU Member States with detailed information on the operation of the early warning system and its possible application in other countries.

3.2 Re-siting the THRUST project instruments: After the meeting mentioned above, it is planned that some of the project instruments will be transferred to Iquique in order to monitor possible seismic and tsunami activity in the future.

NATIONAL REPORT OF COLOMBIA

1. ACTIVITIES CARRIED OUT BY COLOMBIAN BODIES

a. Colombian Institute of Hydrology, Meteorology and Land-use Planning (HIMAT)

(1) Network of tide stations: One of the main objectives related to the network of tide stations was the improvement of the tide stations at Buenaventura, Tumaco and Cartagena. To that end, greater care was taken in operating them and considerable improvements were made in their physical structure by the Agustin-Codazzi Geographical Institute (IGAC). The tidal data program has now been transferred entirely to HIMAT, which assumed responsibility for it on January 1st, 1987. Since then,

Table 1

DATE	LATITUDE	LONGITUDE	MAGNITUDE	ACTION TAKEN
04/08/85	34.4 S	7136 W	6.0	Tide station interrogated
09/19/85	17.8 N	102.3 W	7.8	Tide station interrogated
05/07/86	51.3 N	175.0 W	7.7	Regional alert
10/20/86	28.2 S	176.6 W	8.1	Regional alert
03/05/87	24.5 S	70.6 W	7.3	Tide station interrogated

HIMAT has maintained and operated the tide gauges, continued to process information collected in the stations, prepared tide predictions for 16 points on the Pacific coast for 1987 and renewed the instruments at the Buenaventura station by installing a long duration Stevenson wave recorder, which has been operating and giving good results since June.

(2) Communication network: At present, warnings on earthquakes and possible generation of the tsunamis arrive through the Civil Aviation AFTN network at the Aeronautical Meteorology office of HIMAT at Eldorado Airport in Bogota from the Pacific Tsunami Warning Center (PTWC). Several test runs have been carried out and have so far given good results. However, HIMAT has also offered the use of telex No. 44345 as an alternative means of communication. The Telex is located in the administrative offices and is operating from Monday to Friday between 13.00 and 22.00 GMT (Greenwich Mean Time). Telex No.42539, was installed in the HIMAT offices at Eldorado airport, and came on line in early July. It operates continuously, 24 hours a day, thus providing total coverage for the reception and transmission of information and constitutes the most efficient link between PTWC and HIMAT.

(3) Future plans: Short-term plans include computerization of the tide stations and the installation of another completely computerized meteorological-oceanographical station on Malpelo Island, as the main tsunami risk in Colombia stems from locally generated tsunamis that strike our Pacific coastal areas 30 minutes or less after an earthquake occurs; consequently, the system will be functional and effective when the network of stations is computerized.

It is planned that two radio communication stations will be acquired for the Buenaventura and Tumaco stations in order to have an efficient warning and information-exchange service with the National Meteorological Center in Bogota, and, through it, with the Global Telecommunications System.

b. National Geological Mining Research Institute (INGEOMINAS)

(1) Training: During the last quarter of 1985, direct participation by INGEOMINAS in tsunami precaution activities consisted exclusively by attending the course entitled "Training for ITIC Visiting Experts", held at ITIC in Hawaii, Dr. Clemente Ropain, was trained at ITIC from 1 October to 15 November 1987. During this training course, Colombia joined the communication plan via AFTN (Aeronautical Fixed Telecommunications Network) and via telex through the HIMAT station and PTWC.

(2) Seismographical network: During this same period, following the Nevado del Ruiz volcanic disaster, INGEOMINAS set up the Manizales Seismological and Volcanological Observatory at the end of November 1985, and since then, work has been done on the collection, processing and dissemination of all seismological and volcanological information concerning Nevado del Ruiz.

In 1986, seven seismological stations were set up which have furnished some information about the volcano's activity.

Since January 1987, INGEOMINAS has been working on the selection and study of sites for the establishment next year of 11 seismological stations that will form part of the national seismic network (Bogota and Popayan modules). The southwestern network, which is being installed and managed by Valle University, and the Medellin and Bucaramanga networks, yet to be established, will become part of this future national network.

(3) Future plans: As part of the Master Plan for International Tsunami Warning Operations, it is necessary for the National Committee to begin a campaign for the implementation of the preliminary project for a local network comprising of the seismological and tide stations to be installed at Buenaventura, Tumaco, Bahia Solano and Malpelo, which could link up with the National Seismic Network due, hopefully become reality towards the end of 1988.

c. Colombian Andean Geophysical Institute (IGA)

(1) Bibliographic research: As part of IGA's normal work, under the Pacific Coast Seismicity Project, the Institute started to compile bibliographic information in October 1985, on the historical seismicity of the region and publications on earthquakes occurring in the area under study and earthquakes that did not have their epicenter in that region, but caused damage because of their intensity.

(2) Seismic research: Work is being done on the analysis of seismograms. Much of the information on epicenters located in the Colombian Pacific region from 1968 to 1981 has now been compiled.

(3) Operation of Equipment: The seismological equipment installed in Medellin, Manizales, China, Cali and Pasto has been inspected and kept in perfect working order.

(4) Future plans: Continuation of the work on the

preparation of seismic-risk and isoseismal maps is being compiled. Seismograms and accelerograms existing at the Institute or recorded in the future, will also be analyzed.

d. Colombian Civil Defense with responsibility for the Pacific Coast

(1) Organization:

UNIT	DISTRICT	NO. OF UNITS	VOLUNTEERS
XVI	Group Valle	53	1629
XVII	Group Cauca	21	715
XIX	Group Narino	31	1063
VI	Special area Choco	23	340

(2) Training: During the period 1985-1987, the staff gave various training courses in accordance with the provisions of the training plan for 1985-1987.

These courses were basically designed to prepare volunteers to assist in the prevention and emergency forces and possibly to participate in the rehabilitation and recovery of areas affected by a disaster. It should be pointed out that preventative activities are given high priority in the training of volunteers.

(3) Communication network: At the level of the Regional Civil Defense Groups in the area corresponding to the departments of Valle, Cauca, Narino and Choco on the Pacific coast, there are HF-VHF and microwave communication facilities in the regional headquarters.

2. MASTER PLAN FOR INTERNATIONAL TSUNAMI WARNING OPERATIONS:

The General Secretariat of the Colombian Oceanographic Commission reviewed the document and considered it very complete and of great use to ITSU member countries.

3. ELEVENTH SESSION - STORM SURGES SYMPOSIUM:

The General Secretariat of the Colombian Oceanographic Commission approached members of the National Tsunami Warning Committee and the National Oceanographic Council about the possibility of sending one delegate to attend the meeting in Beijing, China, but was unsuccessful in securing funding. The IOC Secretariat was requested to provide support for one expert to attend the symposium.

4. REQUIREMENTS: To be effective, the Colombian Tsunami Warning System must be computerized; support is therefore being requested in the following areas:

a. Staff training: This takes first priority, although the the standard of scientific and technical experience in Colombia is high, specialized training is required for:

(1) the development of the computerized system;

(2) the installation and maintenance of equipment;

(3) National Civil Defense programs.

b. Instrumentation:

(1) Experience gained under the THRUST program is considered to be most useful for the Colombian Warning System. Information is therefore requested on the results obtained to date.

(2) Advisory services are requested from experts with experience in computerized tsunami warning systems to provide recommendations based on cost effectiveness:

(a.) the number, type and location of the seismometers and computer facilities (both hardware and software) required for rapid determination of the hypocenter and magnitude of strong earthquakes.

(b.) the number, type and location of the most suitable tide gauges for a computerized network.

(c.) the most adequate communications system to meet the needs of the tsunami warning system.

c. Financing:

Although costs cannot be calculated until instrumentation requirements are adequately determined, it can be estimated that for a completely computerized tsunami warning system, costs are likely to exceed US $500,000.

IOC is therefore requested to give support through ICG/ITSU and ITIC to the request of international funding (from UNDP and/or other suitable agencies) for the establishment of a computerized tsunami warning system in Colombia, and to provide advice and assistance in the preparation of the request.

NATIONAL REPORT

OF FRANCE

(French Polynesia)

This report will state essentially on the Tsunami Warning dispositions in French Polynesia, as the risk of distant Tsunami there, is much higher than in New Caledonia.

The Laboratoire de Geophysique of the Commissariat a l'Energie Atomique is in charge of the Tsunami warning system in French Polynesia. It makes use of the information obtained from the Reseau Sismique Polynesien (RSP) (Polynesian Seismological Network), the Tide Gauge Handar Data Collection Platform of Easter Island, Nuku-Hiva, Rarotonga and soon Niue, but also of those yielded by the Pacific Tsunami Warning Center in Honolulu. All this information is centralized at the headquarters of the Laboratoire de Geophysique and of the Reseau Sismique Polynesien, which is also the Polynesian Center for the Prevention of Tsunamis (CPPT) - (Polynesian Tsunami Warning Center). The CPPT which elaborates the Tsunami warnings, is situated on a hill slope near the city of Papeete in Tahiti.

For the last 2 years, the Center Polynesien de Prevention des Tsunamis has essentially dealt with a new magnitude scale (Mantle wave magnitude: Mm). Consequently, for more efficiency and reliability, we have changed our criteria for Tsunami prediction. Quantification and treatment of the seismic waves for an automatic determination of the magnitude Mm and the seismic moment, have been completely automated.

I. Magnitude Mm

The rapid measurement, if possible, in real-time and at a single seismic observatory of the "size" of an earthquake remains a fundamental aspect of Tsunami prediction. But it has long been known, that any magnitude scale measured at a constant period T saturates when the duration of the rupture along the fault becomes comparable to T. Thus, for very large earthquakes, and in particular, those carrying Tsunami risks, Ms loses significance. On the other hand, the seismic moment Mo introduced by Aki (1967), measured at least in principle, at zero-frequency, keeps growing with earthquake size, rather than saturate. In addition, and because of the linearity of the law of mechanics, the excitation of all seismic waves from the earthquake source is proportional to the seismic moment (Mo).

With the development of broadband seismographs providing adequate records of mantle Rayleigh waves even for relatively moderate earthquakes, it is possible to envision their systematic use in the rapid estimation of the "size" of teleseismic events, in particular, of their seismic moment. Since 1973, the Reseau Sismique Polynesien (RSP) has been equipped with such broadband records. Presently, the response of this system is flat in displacement from 1 s to 300 s and decreases by a factor of

$$\sqrt{2} \text{ at } 1000 \text{ s}$$

Talandier and Reymond (1986) have proposed the real-time estimation of Mo through the use of the low frequency magnitude scale Mm, based on the measurement of mantle Rayleigh waves (Rl) and a variable period in one single station, and such that:

$$Mm = \log_{10} Mo - 20 \qquad (1)$$

where Mo is in dyne-cm

Okal and Talandier (1987) have established the theoretical background justifying this approach, and explicated Mm as

$$Mm = \log_{10}(X(w)) + C_D + C_S + C_O \qquad (2)$$

where X(w) is the original amplitude of R1 at angular frequency W, C_D a distance correction, C_S a source excitation correction; both corrections are frequently dependent. C_O is a "locking" constant. The distance correction C_D contains the geometrical spreading factor :

$$\log \sqrt{\sin \Delta}$$

and the frequency dependent correction for an elastic attenuation. The latter takes into account regional variations in group velocity and Q.

A frequency-dependent correction C_S is then applied to compensate for the variation of surface wave excitation with T. They have justified the expression:

$$C_S = 2.0398\,\theta - 1.3122\,\theta^2 + 0.39342\,\theta + 3.9335 \qquad (3)$$

where $\theta = \log_{10} T - 1.7657$

The magnitude Mm is calculated from the first passage of Rayleigh waves (vertical component) in a single station. Directly proportional to the logarithm of the seismic moment, the Mm magnitude does not sustain a saturation effect, as the magnitude commonly used: Ms, and all the more Mb. This new magnitude scale is perfectly adapted to Tsunami prevention which needs to evaluate the source size, in a single station and as far as possible in

real-time. Furthermore, Mm has been set up to give Mm ≅ 10 for the strongest earthquakes, corresponding to seismic moments near 10^{30} dyne-cm. Hence with Mo of 2 x 10^{30} and 8..2 x 10^{30} and 8..2 x 10^{29} dyne-cm, the earthquake of Chile (22 May 1960) and Alaska (28 March 1964) would be respectively Mm = 10.3 and 9.9 and the risk of major Tsunami (Earthquake of 5 x 10^{28} dyne-cm) would exist starting from Mm = 8.7 up.

The experimental approach used about one hundred earthquakes for the last 15 years, recorded by the seismological station of Papeete in Tahiti. This study has proved a very good correlation between Mm and log Mo.

This new magnitude scale, used for about 2 years by the CPPT, allowed to obtain especially a correct estimate of Mo (Mo = 1 x 10^{28} dyne-cm) for the Aleutian Islands earthquake on 7 May 1986; consequently no Tsunami warning was issued for French Polynesia.

II. Automation of the Measurements

Talandier and Okal (1987) have developed an algorithm for automation of the measurement of Mm, which is now used systematically by the CPPT.

First, a strong-event detector is triggered, based on the use of 9 short period stations of the 350 km aperture Polynesian array continuously telemetered to PPT, and of a classic multiple criterion of amplitude threshold, frequency content, duration and simultaneity. Next, an automated locator uses P times across the array to estimate an epicentral region and an arrival window for R1. It then triggers acquisition into the computer of 819.2 s* at a 0.2 s sampling rate. The computation of Mm then proceeds in 2 independent ways, providing redundancy of the final results:

Frequency-Domain Measurements

The time series is simply run through a standard FFT algorithm and the correction C S applied at each FFT period between 50 s and 300 s. The regionalized correction C d is computed for the epicenter. Mm is then computed from:

$$Mm = \log_{10} X(w) + C_D + C_S - 1.08 \qquad (4)$$

at various periods, and the largest value retained. (X(w) is in μm-s).

* A duration of 819 s (13.7 minutes) is long enough to record all the Rayleigh waves. The sampling step of 0.2 s could be larger, according to the frequency spectra of these waves.

Time-Domain Measurements

The signal is run through a band pass filter eliminating periods outside the 50-300 s range. The resulting time series is searched for subsequent maxima and minima reaching at least 10 percent of the absolute maximum amplitude of the signal; the resulting amplitudes and the periods of the corresponding arches are retained. For each of them, Mm is computed through:

$$Mm^{TD} = \log_{10}(a.T) + C_D + C_S - 1.20 \qquad (5)$$

and the maximum value retained (a is in um and T in s).

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III TSUNAMI WARNING METHODS USED BY THE CENTER POLYNESIEN DE PREVENTION DES TSUNAMIS

The ability to determine, as soon as Reyleigh waves arrived, the seismic moment of great earthquakes led to fundamentally revising Tsunami warning methods used by the CPPT. From now on, T waves are not the basis of risk estimation *.

In fact, we can deduce the source dimension from 2 seismic waves: T waves or Reyleigh waves. The latter more reliable and easier to use, don't need regional corrective factors. Furthermore, they better correlate with the

source area parameters. Thus, we first take into account the seismic moment, deduced from the Mm magnitude. T waves are used only to confirm the submarine nature of the earthquakes and so, their Tsunamigenic ability.

On the basis of 15 Tsunami records by the Papeete tide gauge since 1960, we have determined various risk levels according to the seismic moment. Close to us, the "Tonga, Kermadec, Samoa" area (2,200 to 3,000 km) has been separated from the other seismic regions in the Pacific (7,500 to 10,000 km).

Risk Levels

Five cases have been defined:

1) $Mo < 10^{27}$ - $Mm < 7.0$ (Mo in dyne-cm)

There is no Tsunami risk.

2) $10^{28} > Mo \geq 10^{27}$ - $8.0 > Mm \geq 7.0$

A great Tsunami is still unlikely, but it is necessary to observe T waves. We may remember the 1 April 1946 Aleutian Islands seism, Ms = 7.4 (Mm 7.2) which generated one of the two strongest Tsunamis of the last 150 years.

*Since the '60's, the Laboratoire de Geophysique has used the T wave duration to estimate the Tsunami risk.

3) $5 \times 10^{28} > Mo \geq 10^{28}$ - $8.5\ Mm \geq 8.0$

A Tsunami is likely, but it should not be important (except particular conditions as we have seen above) for areas far from the epicenter. Anyway, T waves observation remains necessary.

4) $2.5 \times 10^{29} > Mo \geq 5 \times 10^{28}$ - $9.25 > Mm \geq 8.5$

A dangerous Tsunami is very likely. Immediate Preliminary warning if the epicenter is in the Samoa, Tonga Kermadec area or closer than 4,000 kms.

5) $Mo > 2.5 \times 10^{29}$ - $Mm > 9.25$

Immediate warning if the epicenter is situated in the Samoa, Tonga Kermadec area, and preliminary warning if it is situated in the other subduction zone of the peripheral Pacific.

T-waves criteria

In any case, long and strong T waves confirm the submarine or close to a coast nature of the seismic source, and so, the possibility of generation of a Tsunami. The maximum amplitude duration, related to the fault length, will be used to estimate this parameter and to confirm the seismic moment.

The duration above a 100 micro-meters threshold will be a criterion for comparison with reference records for this area.

For French Polynesia, 2 major risk cases have been retained.

1) Tonga, Kermadec, Samoa (distances less than 4,000 km)

$$Mo \geq 5 \times 10^{28} \text{ dyne-cm}$$

2) Other epicenter

$$Mo \geq 1 \times 10^{29} \text{ dyne-cm}$$

Mo greater than 1.10 29 dyne-cm

In case of major risk, the warning is confirmed at least 4 hours before the arrival time of the Tsunami in Polynesia, even if we do not know anything about the amplitude.

Of course, prediction takes into account in priority, data from the tide stations sent by the PTWC and data from Handar Goes Platform of Rarotonga, Nuku-Hiva, Easter Island and in a short time Niue, received in real-time at the CPPT.

IV. DIFFUSION OF THE WARNING IN FRENCH POLYNESIA

The size of the territory and the dispersion of some of its 160,000 inhabitants over about 100 islands or so, present a real problem for the diffusion of the Tsunami alert by broadcast at night, that is outside the normal local radio broadcasting hours. At present, the important towns and the most vulnerable points are equipped with standby receiving stations with automatic release. Still, in spite of the efforts spent within the last few years, many thinly populated islands or isolated and inaccessible regions of the main islands remain without such equipment.

V. TSUNAMI PREVENTION

The Tsunami Warning issued by the CPPT triggers the application by and of the governmental ORSEC (Assistance Organization) program. This plan aims the population to be informed on the potential danger as soon as possible and to be advised on all protective actions to be taken at all levels:

- On the high islands, the evacuation of the inhabitants from vulnerable zones (bays, coastal plains, small slope river sides) to nearest hills is the simplest thing to be done.

- On the low islands (atolls), because of the low altitude of emerging land and taking into account the absence of noticeable relief and possible shelters, particular measures have to be adopted. Fortunately, considering the Tsunamis registered during the last century, these low islands seem to be less vulnerable.

VI. TIDE GAUGE STATION

The CPPT collaborates with the U.S. National Oceanic and Atmospheric Administration (NOAA), to finance a new tide gauge Handar Data Collection platform in Niue. This station complements the other stations of Easter Island, Nuku-Hiva, Rarotonga and local ones in French Polynesia in Tahiti and Rikitea. The CPPT will thus have at its disposal, 6 tide gauge records, practically in real-time..

Further information regarding any aspect of this report may be obtained from the National Contact for France:

Dr. J. Talandier
Director, Laboratoire de Geophysique B.P. 640
Papeete - Tahiti
Polynesie Francaise

NATIONAL REPORT OF JAPAN

The Japan Meteorological Agency (JMA) is responsible for the Tsunami Warning Service in Japan. Tsunami warning and advisories are handled by the Earthquake and Tsunami Observations (ETO) Division in the Seismological and Volcanological Department. Because of the localized nature of earthquakes and Tsunamis, the Japanese islands are divided into 6 regions to be covered by local centers located in 6 key cities: Sapporo, Sendai, Tokyo, Osaka, Fukuoda and Naha. These local centers are deployed in the District Meteorological Observatories under JMA.

Individual local centers issue warnings and advisories for Tsunamis generated by earthquakes in the responsible see areas, within 600 km from the designated stretch of coastline. For the areas outside the 600 km zone, the ETO Division, serving both as the local center for the Tokyo region and as the national center, assumes responsibility, relying much on the information from PTWC in Honolulu.

PRESENT STATUS OF TSUNAMI WARNING OPERATION

JMA has, at its Tokyo Headquarters, a computerized meteorological telecommunication computer system called ADESS (Automated Data Editing and Switching System). A smaller version of ADESS, called local ADESS, or L-ADESS, has been installed at each of the above-mentioned local centers over the past 7 years. Other than meteorological data, L-ADESSes collect and process seismological data. Digitized seismometer signals from 10 to 20 selected stations are continuously fed to each L-ADESS. When an earthquake occurs, the signals exceeding a threshold value activate a disk drive, pen recorders and a buzzer.

The alert duty officer enters P, S times and amplitudes of seismic waves into the computer by using an X-Y digitizer. The computer determines, through dialogue with the duty officer, the location and magnitude of the earthquake, the possibility of Tsunami generation, the level of Tsunami warning and then produces messages of warning and/or advisory. The warning messages are automatically transmitted to concerned field offices under JMA, various organizations concerned with disaster mitigation and the media including TV stations.

DEVELOPMENT OF EARTHQUAKE PHENOMENA OBSERVATION SYSTEM (EPOS)

Tsunami warnings have practically been issued within 20 minutes. However, Tsunami waves occasionally arrive in less than 10 minutes and warnings are not always available in time. The JMA has developed and installed a new automatic data acquisition and processing system which is the Earthquake Phenomena Observation System (EPOS) .

The EPOS is based on an automatic detection of events, and identification of P and S wave arrival times in the telemetered seismic signals by use of the AR (Auto-Regressive) model. The epicenter location, focal depth and magnitude are also determined automatically. If the magnitude and location of an earthquake are appropriate to generate Tsunami, the warning service is successively conducted by the System. Based on the results obtained from the above analyses, a final decision on the Tsunami is given by the duty officer and Tsunami messages are automatically dispatched through the system to various organizations concerned. The number of seismic stations connected to the system are more than 60 including 2 Permanent Ocean Bottom Seismograph (PBOS) systems.

Another important purpose of the EPOS is to improve the earthquake prediction system for the coming Tokai Earthquake. In order to monitor and identify precursory anomalies, the EPOS processes the telemetered signals on the crustal movement including strain-meter, tilt-meter, extension-meter, ground water level-meter and tide gauge installed in the Tokai district.

Since the EPOS has been installed at the Tokyo Headquarters in March 1987, the Tsunami warning service in the Tokyo district has been operating in both the EPOS and the conventional L-ADESS method. After 5-months parallel operations, JMA will move the entire Tsunami service to the new system in August 1987. This system will shorten significantly the time for issuing Tsunami warnings. It is hoped to deploy such new systems at all local Tsunami centers in Japan.

REPLACEMENT OF JMA STRONG MOTION SEISMOGRAPHS

The JMA seismic observation network includes about 100 sets of strong motion seismographs. Their magnifications are the one in ground amplitude and natural periods of pendulums are about 6 seconds. These mechanical seismometers had been installed in the 1950's and their property are not sufficient for accurate Tsunami forecasting. For the purpose of improving the Tsunami warning system, JMA began installing electromagnetic strong motion seismographs with a digital recording and telecommunication system since 1987.

Tentative specifications of new seismographs are as follows:

Frequency range:	0.05 Hz (20 sec or more) - 20 Hz
Dynamic range:	10 mgal - 1,000 gal (in acceleration)
Digital data sampling rate:	50 samples/sec
Data length:	16 bits/sample
Delay time:	30 sec

JMA will replace 72 sets of old type instruments with the new ones by the end of March 1988. Wide ranges in both frequency and dynamic are essential for accurate Tsunami forecasting. These modern instruments will be expected to bring better results in the Tsunami warning service in Japan.

TSUNAMI FROM THE ALEUTIAN EARTHQUAKE OF 7 MAY 1986

Tsunami waves caused by the earthquake (M:7.7) of 7 May 1986 in the Aleutian Islands were recorded throughout the Pacific coast of the Japanese Islands. The first wave of the Tsunami reached Miyako in Northern Honshu about four and a half hours after the shock. Some of the maximum wave heights are: 11 cm at Kushiro, Hokkaido; 10 cm at Miyako, Northern Honshu and 16 cm at Tateyama, Central Honshu. On the basis of communications with PTWC in Honolulu, a Tsunami advisory "TSUNAMI ATTENTION" had been issued for North and Eastern Japan in 3 hours advance and for Western Japan, in one hours advance. No damage was reported with these Tsunami waves.

NATIONAL REPORT OF THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

The Democratic People's Republic of Korea has not yet had enormous Tsunami events but we have been influenced by the damage from medium scale Tsunami events frequently in the last 10-15 years on our 2 seas, East and West.

In this condition our important considerations are turning to mitigate for protection of damages from Tsunami, and now we have taken the necessary steps to improve research activities of Tsunami and immediate communication systems.

For this purpose we feel strongly in participating on the International Tsunami Warning System. Since we joined the system in June 1986, we became a member of this group. We shall participate actively in the work of this group with international duty and national requirements.

We are now consolidating the Tsunami Monitoring and Warning System in our coastal areas. We have made a national relating system between the oceanographic centers and the Seismological Institute.

The International Communication point for the Tsunami Warning System in our will be located in the National Meteorological Center in Pyongyang, which is provided with a global telecommunication and data processing system.

I should like to inform briefly that recently our government has re-established our National Oceanographic Commission, including 9 members who are representatives from oceanographic-related organizations in the whole country. Mr. Baek ok hyon, Deputy Director-General of the State Hydrometeorological Service was appointed Chairman of our National Oceanographic Commission and the Function of its Secretariat given to the Service, too.

The Oceanographic Research Institute of the Korean Eastern Sea and the Oceanographic Research Institute of the Korean Western Sea are the main oceanographic centers of the East and West, which are controlled by the State Hydrometeorological Service. They take important tasks in accordance with the National Economical Development Plan. The Institute of the East Sea's main tasks are composed of fishing, oceanography and navigation and the Institute of the West Sea's main tasks is composed of oceanographic engineering for marine construction and reclamation of tideland, of which the main tasks are the research of all kinds of oceanographic elements and marine meteorology.

NATIONAL REPORT OF NEW ZEALAND

1. No Tsunamis of significance have been recorded since the last report to ITSU-X (Sidney, B.C., Canada, 1-3 August 1985).

2. New Zealand has taken part in a number of Tsunami message passing exercises in accordance with the Pacific wide procedures. These exercises continue to be of excellent value; not least because of the tests to the country's internal Tsunami warning system which can be initiated in conjunction with the passing of test messages between New Zealand and Hawaii.

3. The Ministry of Civil Defense liaised with representatives of the United Kingdom government and the Director, International Tsunami Information Center concerning the passing of Tsunami warnings to Pitcairn Island. There is some evidence to suggest that Pitcairn Island has felt the effects of Tsunamis in the past. Although no final decisions have been made regarding Pitcairn, I have undertaken to keep the representative of the United Kingdom government informed of developments in Tsunami warning system planning.

4. The Ministry of Civil Defense intends to pursue investigations into ways of improving the New Zealand Tsunami warning system. It is hoped that this will include additional instrumentation. The aim will be to install instruments that will benefit not only New Zealand but also the wider Pacific community.

5. The Ministry of Civil Defense in New Zealand welcomes the opportunity to be represented at this conference.

A REPORT ON THE EARTHQUAKE THAT OCCURRED IN BAY OF PLENTY 2 MARCH 1987

An earthquake registering 6.5 on the Richter scale occurred in the Bay of Plenty region at about 13h45 on Monday 2 March 1987. The earthquake was felt throughout the region. Felt reports were also received from locations well outside the Bay of Plenty region e.g., this headquarters was contacted by people who had felt the shock in the Auckland district.

The region had experienced a series of earthquake shocks of various intensity for a number of days preceding 2 March. None of these had caused any significant damage to property but they were of sufficient intensity and frequency to cause concern among the population.

This headquarters was notified of the earthquake by telephone reports from Rotorua and Tuaranga. These reports did not contain any damage assessments but indicated that the effect of the earthquake was expected to be severe. The headquarters was activated as were civil defense headquarters at Rotorua, Whakatane, Tauranga and Kawerau. Although there were no great delays in activating, the recollections of some people contacted indicated some disbelief that an earthquake had in fact occurred.

Although reports from the earthquake-struck region into the headquarters came from a number of sources, the reports, at first tended to be very general in nature.

It was about 2 hours after the earthquake occurred that significant detailed information was received. This concerned damage to the hospital at Whakatane and possible damage to the Mataheina Dam. In addition to the foregoing, some specific information emerged concerning blocked highways and damage to railway tracks.

Although minor damage extended over a wide area, the main effects of the earthquake were concentrated in the line Kawerau, Te Teko, Edgecumbe. Extensive damage was caused to house chimneys (more than 800 in Kawerau alone); tiled roofs suffered badly and many houses were moved from their foundations. In the previously named district, considerable damage was caused to property inside homes where many cupboards were emptied of their contents. Many unsecured fittings were overturned and much damage created. In the Edgecumbe/Te Teko areas, extensive damage was caused to underground services. Water and sewer lines were damaged in many places, some beyond repair. Industrial complexes did not escape the force of the earthquake. Extensive damage to plant and machinery was experienced at the Tasman Pulp and Paper Mill (Kawerau) and the Rangiteiki Plains Dairy Company factory (Edgecumbe). Schools in the Edgecumbe/Te Teko district were closed because of damage to administration and classroom blocks, in addition to the underground services damage, already mentioned.

A state of Regional Civil Defense Emergency was declared by the Chairman of the Bay of Plenty United Council at 15h17 on Monday 2 March. The regional headquarters was activated at Rotorua and remained active until the regional emergency was terminated at 18h00 on 5 March. The Whakatane Civil Defense headquarters was activated in Whakatane and remained established there until late PM on 4 March when the headquarters moved to Edgecumbe. The Kawerau Civil Defense headquarters was also activated. The Tuaranga Civil Defense Organization was activated early in the afternoon of 2 March and remained activated at a reduced level until the termination of the Regional Civil Defense Emergency.

Communications were maintained between all operating headquarters using telephone-radio and in some cases telex and burafax.

The earthquake and subsequent aftershocks caused many people to move out of their homes on 2 March. Of those, many remained near their district camped in backyards etc., but a large percentage either left the district completely or moved to a number of maraes* in the district. The Onepu Marae at one stage had nearly 5,000 people within its precincts. Many of those who left their homes returned after about 4 or 5 days but some of them were unable to, because of the damaged state of the houses, to occupy their homes.

Following the termination of the regional civil defense emergency, a state of Local Civil Defense Emergency was declared in the Whakatane district. This remained in force until 18h00 on Thursday 12 March.

A Disaster Recovery Coordinator was appointed on 5 March. He took up residence in accommodation at Edgecumbe and worked in conjunction with the civil defense authorities until the emergency was terminated on 12 March, after which the Disaster Recovery Coordinator assumed responsibility for the subsequent relief coordination.

*MARAE - Maori meeting place where tribal groups assemble to discuss events of importance and where Maori cultural and spiritual values predominate. The Marae complex includes communal sleeping and feeding resources.

NATIONAL REPORT OF PERU

I. BACKGROUND

Peru, as a member of the Pacific Tsunami Warning System has developed several activities during the period 1985-1987 in order to upgrade its National Tsunami Warning System and to train local observers, Civil Defense authorities and the general public in the basic aspects of Tsunamis and precautions against its potential effects.

This report describes the above-mentioned activities as coordinated by the Peruvian Hydrographic Office, the official representative of the country to the Pacific Tsunami Warning System.

II. THE NATIONAL TSUNAMI WARNING SYSTEM IN PERU (NTWS)

The Peruvian Government created the National Tsunami Warning System in 1970, and designated the Peruvian Hydrographic Office as its official representative to the Pacific Tsunami Warning System. The Peruvian Hydrographic Office, coordinates the national activities related to the National Tsunami Warning System with several government offices as follows:

The National Cooperation of Airports (CORPAC): It is through this office that the Hydrographic office receives the Tsunami messages from Honolulu. This link is provided by a telex line exclusively operated for the NTWS between the Jorge Chavez National Airport in Lima and the Hydrographic Office in Callao, about 15 kilometers apart in distance. It also has a regular phone line and a backup magnetic phone system to assure permanent communication between offices.

The Geophysical Institute of Peru: This office manages the National Seismic Network and reports to the Hydrographic Office the intensity and epicenter of earth and seaquakes that occur in Peruvian territory to re-transmit the information to Honolulu. The Hydrographic Office and the Geophysical Institute are linked by regular phone line and a special backup magnetic phone system exclusively operated by the National Tsunami Warning System.

The National Civil Defense Office: This office has the responsibility of coordinating all actions with the civilian population in order to mitigate the efforts of any natural hazard (earthquakes, landslides, floods, Tsunamis, etc.).

The National Civil Defense Office has a network of local authorities throughout the country to carry out all activities. In coastal towns and cities, they are responsible for preparing evacuation plans for the population according to the potential risk of floodings due to the effect of a Tsunami. The Hydrographic Office and the Civil Defense Office are linked by a regular phone line and a special backup magnetic phone line exclusively operated by the NTWS.

The National Civil Defense Office has a Permanent Scientific Committee that helps the office in evaluating the potential risks of natural hazards and the design of policies to mitigtate these risks. One of the members of this committee belongs to the National Tsunami Warning System.

The National Tsunami Warning System operates a communications network to receive and disseminate the Tsunami warnings using the national telephone and telex systems, and some special circuits assigned by the National Telecommunications Company. It also uses the Naval Communication facilities to relay the messages to the Captain Port Authorities (Peruvian Coast guard) and ships anchored in ports and bays along the coast.

III. THE NATIONAL NETWORK OF TIDE STATIONS

The national network of tide stations that participates in the National Tsunami Warning System consists of 7 stations. These stations are managed by the Department of Oceanography of the Hydrographic Office. Table 2 shows the station names, locations and their instrumentation.

The tide stations at Paita and San Juan have recently been upgraded with new tide houses and are now integrated to the network. The Handar platforms installed in Callao (1984) and Lobos de Afuera Island ((1985) are operating normally. In 1984, when the Hydrographic Office moved to its new building in Chucuito (Callao) a special circuit was installed to link the Tsunami Warning Office with the La Punta tide station and a Bristol tide repeater provided by the PTWS office was installed. This allows a real-time control of sea level changes and reduces considerably transmission times of messages requiring sea level information.

Plans for the near future: In order to upgrade the operation of the National Tsunami Warning System in Peru, the following activities have been planned for the near future.

A. Reduction of Transmission Times Hydrographic O - CORPAC

A decoder will be installed in the telex lines in COEPAC in order to automatically re-route the Tsunami messages coming from PTWS to the Hydrographic Office. This will significantly reduce the transmission times between CORPAC and the National Tsunami Warning System.

B. Access to Communication Systems of Handar Platforms

The Hydrographic Office, since 1986 has the capability of receiving in real-time (via modem) the information transmitted by 2 meteorological platforms installed along our coast within the context of the TOGA (Tropical Ocean Global Atmosphere) program. This is done through a downlink station managed by the Peruvian Geophysical Institute in Ancon, about 35 kilometers south of Lima. Due to limitations in equipment, this downhill station can actually only access one channel assigned to the meteorological platforms (channel 9). However, due to a cooperation program signed this year by the Canadian and the Peruvian Government (PERCEP program) the Ancon station will have a new computer and equipment which will allow us to receive in real-time the tide data transmitted by the Handar platforms by the end of this year.

C. Training of Authorities and Port Captains

During the second half of 1987, 2 people from the Hydrographic Office will visit local Civil Defense Authorities and the Port Captains along the coast to conduct short seminars and the coordinations in order to improve the efficiency of the operation of the National Tsunami Warning System, and to start a program of exercises in the communications network.

IV. THE NATIONAL NETWORK OF SEISMIC STATIONS

The Peruvian Geophysical Institute manages a network of 33 seismic stations along our territory. This includes a telemetric network, a teleseismic network and a semi-portable one.

The telemetric network is composed of 7 stations equipped with a microwave telecommunication system

Table 2

STATION NAME	LATITUDE	LONGITUDE	EQUIPMENT
TALARA	04 34 S	81 17 W	1 Standard, 1 Digital
PAITA05	04 S	81 06 W	1 Standard, 1 Digital
LOBOS DE AFUERA	06 56 S	80 43 W	1 Standard, 1 Digital
CHIMBOTE	09 04 S	78 35 W	1 Standard, 1 Digital
CALLAO	12 04 S	77 10 W	1 Standard, (LA PUNTA) 1 Digital
PISCO	13 48 S	76 17 W	1 Standard (SAN MARTIN) 1 Digital
SAN JUAN	15 21 S	75 10 W	1 Standard, 1 Digital
MATARANI	17 00 S	72 06 W	1 Standard, 1 Digital

connected to the central computer in Lima. This allows an almost real-time evaluation of the information in order to determine the epicenter, magnitude and focal point of earth and seaquakes. This network only receives high frequency signals which correspond to local seismic activity. The teleseismic network is integrated via phone lines and is equipped to receive relatively distant signals. The Peruvian Geophysical Institute during 1985-87 has done several seismic studies along the coast in order to locate areas of subduction related to the oceanic plates.

Near Future Projects: The Peruvian Geophysical Institute is planning to widen the telemetric network to include the stations of Cuzco, Huancayo and Tacna, and to install 2 new ones at Lobos de Afuera Island and Hormigas Island (Lat. 11 57 S Long. 77 44 W).

V. RECENT ACTIVITIES OF THE NATIONAL TSUNAMI WARNING CENTER

A. New Handar Stations at Lobos Island into the Network

Lobos de Afuera is an island located at Lat. 06 56 S Lon. 80 43 W and well known because of its old guano deposits and large guano bird population. This island is not inhabited except for one keeper and 2 permanent observers from the Hydrographic Office that are responsible for the operation of one meteorological station, one tide station and 2 lighthouses.

In 1985, within the framework of the TOGA project, an automatic Met. station and a Handar telemetric platform were installed. Since then, Lobos Island became part, together with Callao (La Punta) of the network of Handar platforms in the Pacific.

B. Two Tide Stations Upgraded With New Tide Houses

The stations at Paita and San Juan have been upgraded with new tide houses. At Paita, there was only one portable tide gauge at the end of a small pier since 1983. Since June 1987, a new tide house has been built on the ample pier of the National Port Authority. The tide station now has a standard and a digital tide recorder installed, and it is managed by an operator from the Hydrographic Office stationed at the Port Captain's Office in Paita.

In the same way, a new tide house was built in San Juan after the Acari pier was totally repaired. The new station is equipped with a standard and digital tide gauge and is also managed by an operator from the Hydrographic Office stationed at the Port Captain's Office in San Juan.

C. Training Courses for Operators of CORPAC

The Hydrographic Office organized in May 1987 a short training course of a week's duration for the operators of the telex system of the Peruvian Cooperation of Airports. This course was designed to provide basic information about Tsunamis and the importance on the National Tsunami Warning Center to the operators of the telex system of CORPAC who receive the Tsunami messages and re-transmit them to the Hydrographic Office. The course was very fruitful due to the initiative of the operators that were able to detect some weak points in the communication system between CORPAC and the Hydrographic Office which are now being corrected. This experience will determine the convenience of programming other courses with several other parties indirectly involved in the National Tsunami Warning Center.

D. Short Seminars for Civil Defense and Port Authorities

During 1987, a special training program in the form of seminars and on-the-job training has been planned by the Hydrographic Office. These seminars are designed to give local Civil Defense authorities and Port Captains along the coast, information about their role in the case of Tsunami warnings. They will also be useful in evaluating the state of the communication system for each station and to plan a series of communication tests to keep the stations alert and trained. This is the first time that such a seminar will be given to local authorities within their local area. For this seminar, a special pre-recorded 20-minute slide show has been prepared by the Hydrographic Office which includes general aspects about Tsunamis and the operation of the Pacific and the National Tsunami Warning System including sets of safety rules for the population in cases of Tsunami warnings.

E. Preparation of an Audiovisual on Tsunamis

The Hydrographic Office received during 1987 an important economic contribution from the National Council of Science and Technology (CONCYTEC) of Peru to prepare a 20-30 minute duration Audiovisual on Tsunamis and the role of the Pacific and the National Tsunami Warning System. This movie will be shown on public TV stations and used for general training in schools, job training centers and other local Civil Defense centers.

The audiovisual will be filmed by the TV Educational Center of the Catholic University of Peru under the supervision of the Hydrographic Office. The movie will be completed by the end of 1987.

NATIONAL REPORT OF THE PHILIPPINES

I. BACKGROUND

A. Situation

The Philippines, an archipelago with several thousands of miles of coastlines with a number of coastal areas exposed to zones of shallow bathymetry, is subject to foreign and locally generated tsunamis. The probable critical area where a tsunami is most likely to occur is along the Eastern and Northern coastal sections of the country. It is proximate to the volcanic and earthquake belt in the Pacific Ocean bed which has by nature numerous faults, ridges and fractures which are contributing factors to the generation of a tsunami.

The country has been affected by tsunamis in the past. The most destructive so far was in August 1976 in Mindanao. It was a killer tsunami over 10 meters in height, generated by an earthquake in the Moro Gulf with a death toll of 3,702 and damage to properties worth P246.9 Million.

It is in realization of the tsunami potential that the establishment of an effective warning system to the population is very necessary. Although not all areas along the coastal regions may be affected by the tsunamis, the warning system is intended for the tsunami-prone areas already identified.

B. Assumptions

1. The country is capable of providing measures against tsunamis.

2. Resources are available for the establishment of an effective Tsunami Warning System.

3. The general public is aware of the effects of tsunamis and its countermeasures.

4. Local disaster coordinating councils are prepared for any emergency.

C. Definition of Terms

1. Tsunami or Seismic Sea Wave - series of travelling ocean waves of long length and period usually caused by seismic disturbances in the ocean floor or confines, which upon reaching the shore, loses speed but increases in height. Depending upon the residual force upon arrival such waves may rush in shore and cause devastation to human settlements and infrastructures along the shoreline.

2. Advisory Information - information issued when an earthquake, volcanic eruption, landslides, etc., has been detected which is of sufficient magnitude and in such a location that generation of a tsunami is possible.

3. Warning Information - information issued by the Philippines Institute of Volcanology and Seismology (PHIVOLCS) primarily to the Office of Civil Defense (OCD) and other concerned agencies containing positive data that a tsunami threat exists and its estimated time of arrival in the country.

4. Seismograph Station - a station for detecting earthquakes.

5. Tide Station - a station capable of recording changes of water level.

6. Local Disaster Coordinating Council (DCCs) - a group of persons at the provincial, city, municipality and barangay level, duly organized for the purposes of preparing the people under disasters and to control the disaster operations of its tasked units.

7. Tsunami Warning Information Center (TWIC) - a facility presently housed at the Civil Defense Operations Center where tsunami advisories and warning messages or cancellation/all clear information are generally issued.

II. MISSION

1. To prevent loss of lives and minimize loss of properties through the provision of a timely, adequate and reliable Tsunami Warning Information to residents in areas likely to be affected by the Tsunami.

2. To maximize public information drive on the nature and threats of tsunamis and the precautionary measures thereto.

III. EXECUTION

A. Concept of Operation

This plan envisions the establishment of a direct linkage between the Pacific Tsunami Warning Center (PTWC) in Honolulu, Hawaii, the Philippine Institute of Volcanology and Seismology (PHIVOLCS), the Manila Observatory (MO) and the Legaspi Tide Station which is maintained and operated by the Bureau of Coast and Geodetic Survey (BCGS). PHIVOLCS will take care of the local warning dissemination aspect, the MO for the seismological aspect and the Legaspi Tide Station for the observation and recording.

The Tsunami Warning Information emanating from the PTWC will be relayed to the PHIVOLCS and further dissemination to all concerned, especially the Tsunami Warning Information Center of OCD via OCD Command net and the broadcast media.

In the event of an occurrence of a tsunami, the responses of each local Disaster Coordinating Council shall be such that it could cope with large scale displacement of people

including provisions for shelter, food, medical aid and other services such as communication, evacuation, rescue and dissemination of warnings to the people.

This plan is phased as follows:

Phase I: Pre-disaster phase. During this period, the activities to be undertaken are organization training, conduct of public education drive and identification of evaluation sites and routes to safe areas, preparation of tsunami risk maps.

Phase II: Disaster phase. Issuance of tsunami warnings and advisories, reactivation of DCCs evacuation to higher grounds or other sites, provisions of relief supplies, food and medicines.

Phase III: Post phase. Lifting of tsunami warnings, rehabilitation of damaged facilities, provisions of relief assistance to victims, monitoring and assessment of damages.

B. Tasks

Phase I

a. The Office of Civil Defense - Central Office (OCD-CO)

1. Develops a viable Tsunami Warning Network.
2. Assists the PHIVOLCS in the conduct of public information campaigns.
3. Coordinates with print and broadcast media in the airing of precautionary measures on tsunamis.
4. Makes available communication facilities for Tsunami warning dissemination.
5. Makes available the CDOC as a Tsunami Warning Information Center.

b. The Office of the Civil Defense - Regional Center

1 Organizers/reorganizers DCCs which might be affected by the occurrence of a tsunami.
2. Trains/retrains DCC members and volunteer workers.
3. Assists in the conduct of public information campaigns on the dangers of atsunami and the safety measures.
4. Assists MLG in identifying evacuation centers and routes to safe sites.
5. Improves the capability of regional Emergency Broadcast System (EBS).

c. The Philippine Institute of Volcanological and Seismology (PHIVOLCS)

1. Establishes communications linkage with the Pacific Tsunami Warning Center.
2. Detects and locates major earthquakes through their seismograph stations.
3. Prepares tsunami risk maps.
4. Maximizes use of media in the conduct of public information campaign on the dangers of tsunami and its safety measures.
5. Establishes direct communication/linkages with OCD, the Bureau of Transportation (BAT), the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the Office of the President (OP), Kapisanan ng mga Broadkasters ng pilipinas (KBP), the Philippine Constabulary/Armed Forces of the Philippines (PC/AFP) and other agencies and institutions which have a nation-wide system of communications.
6. Undertakes (seismic sea wave of tsunami) research and development/protection program on tsunamis.
7. Evaluates data on advisory and warning messages received from local and international monitoring stations.
8. Designates PHIVOLCS official representative to the TWIC.

d. The Bureau of Coast and Geodetic Survey (BCGS)

1. Monitors the rise and fall of tide.
2. Reports to PHIVOLCS any abnormality in the rise and fall of tide.
3. Establishes communications/linkage with PHIVOLCS and OCD to facilitate transmission of information.

Phase II

a. The office of Civil defense - Central Office

1. Disseminates the Tsunami Warning Information to all concerned upon receipt of Tsunami Warning Bulletin from PHIVOLCS.
2. Convenes the NDCC Action Group with experts from PHIVOLCS.
3. Prepares initial report to the President and to the Chairman, NDCC.
4. Monitors the situation through the OCD, RC, RDCC and other agencies.
5. Keeps the President and the Chairman, NDCC, informed of the situation.

b. The Office of the Civil Defense - Regional Center and Local DCCs

1. Convenes the RDCC and Local DCCs upon receipt

of the Tsunami Warning Information.

2. Coordinates with the Chairman, RDCC for the activation of Regional EBS.

3. Monitors and reports damages if there are any to the Office of Civil Defense - Central Office.

c. The Philippine Institute of Volcanology and Seismology

1. Provides periodic alert advisories to OCD, Central Office for dissemination to all concerned.

2. Issues Tsunami advisories and warning information to OCD, Central Office and monitors the situation.

d. The Bureau of Coast and Geodetic Survey (BCGS) and PAGASA

1. Measures wave amplitude from crest to trough or from trough to crest and reports measurements to PHIVOLCS.

2. Provides details on the wave action and local effects as necessary.

Phase III

a. The Office of the Civil Defense - Central Office

1. Issues official lifting or cancellation of Tsunami Warning Bulletins.

2. Monitors rehabilitation activities.

3. Coordinates with all agencies concerned on their rehabilitation assistance that may be required.

4. Submits reports to concerned agencies, Chairman NDCC and to the President.

b. The Office of Civil Defense - Regional Center and Local DCCs

1. Monitors and reports rehabilitation activities.

2. Coordinates rehabilitation requirements of agencies concerned.

3. Submits reports to OCD, Central Office.

c. The Philippine Institute of Volcanology and Seismology (PHIVOLCS)

1. Issues final Tsunami Warning Bulletins to OCD.

2. Continues monitoring through its seismograph stations.

3. Conducts post-tsunami surveys.

d. The Bureau of Coast and Geodetic Survey (BCGS) and PAGASA

1. Continues monitoring through its tide stations.

IV. COORDINATING INSTRUCTIONS

1. Issuance of Tsunami Advisory Warning Information will be in accordance with the domestic flow of information.

2. All agencies will adhere to established procedures in accordance with the National Calamities and Disaster Preparedness Plan.

3. Tsunami Warning Information shall be disseminated to all agencies concerned.

4. All DCCs and participating agencies will develop a capability for rapid public notification and response to Tsunami warnings.

5. Submission of reports will be coursed to the next higher DCC.

6. NDCC Action Group members shall report to the CDOC for possible assistance they could extend.

7. This Plan will be updated from time to time upon recognition of new planning factors.

V. ADMINISTRATION AND LOGISTIC

A. All agencies shall provide for their logistical support.

VI. COMMAND AND SIGNAL

A. Command

Main Command Post:	Office of Civil Defense Camp Aquinaldo, Quezon City
Regional Command Post:	RDCC Operations Center
Local Command Post:	Local Disaster Operation Center

B. Signal

1. Primary Channel

a. Command/Control

PTWC to PHIVOLCS: Telex

PHIVOLCS to OCD: Landlines/Couriers

b. Warning Dissemination:

OCD Command net EBS

2. Alternate Channel: Couriers

NATIONAL REPORT OF THE UNITED STATES OF AMERICA

I. INTRODUCTION

Tthe United States Tsunami Warning System (TWS) is operated by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). Another component of NOAA, the National Ocean Service (NOS), is primarily responsible for the maintenance of US tide gauges in the TWS. Tsunami research is conducted by NOAA's environmental Research Laboratories and by various universities under the direction of the National Science Foundation. The World Data Center-A (Tsunamis) is operated by NOAA's National Environmental Satellite, Data and Information Service. The US Geological Survey (USGS) is responsible for seismological research and assists TWS through the provision of real-time seismic data and in instrument maintenance and development.

II. GENERAL

The United States has continued to operate 2 major Tsunami Warning Centers since the Tenth Session of the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) in August 1985. These Centers, the Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii and the Alaska Tsunami Warning Center (ATWC) in Palmer, Alaska, have access to large arrays of seismic and tide stations, either directly via telemetry from remote locations or indirectly via messages from local observers.

The more significant developments that have occurred during the period since the Tenth Session include: the continued enhancement of ATWC automated earthquake detection and processing system and the integration of microcomputers into the system; the beginning of the process for replacing the main ATWC computer with a faster and more capable system; the PTWC has begun the integration of microcomputers into its process system and the installation of equipment for the satellite transmission of tide data has continued to expand - these will be addressed in detail in the Eleventh Report. Also, changes to the Eleventh Edition of the Communications Plan for the Tsunami Warning System incorporating all changes proposed by the delegated subsequent to ITSU-X were distributed to all ITSU National Contacts.

In an attempt to provide more meaningful information to ICG/ITSU participants, the United States has implemented new formats for all official bulletins. Three categories of messages will be issued depending on the evaluation of the tsunamigenic potential of the event. A Tsunami Information Bulletin will be issued to advise ICG/ITSU participants of the occurrence of a major earthquake with no Tsunami, or of only a small non-destructive Tsunami. A Tsunami Watch will be issued based on the earthquake evaluation indicating the probability of a destructive Tsunami having been generated. The Watch will meet all criteria of the previous Regional Watch, being restricted to a 6-hour tsunami travel time with urgent action being recommended for those areas within a 3-hour tsunami travel time. Although procedures will remain the same, the text and format of the Watch Bulletin have been completely revised to provide more meaningful information and minimize confusion. The third Bulletin to be issued is a Tsunami Warning, again with the information being reformatted for simplicity and rapid information transmission. Examples of the text for all revised Bulletins are included in the Eleventh Edition of the Communications Plan for the Tsunami Warning System and have previously been disseminated to all National contacts and other interested parties.

The NOS has been working for a number of years on the Next Generation Water Level Measurement System (NGWLMS) which will be the replacement for the current United States tide gauges. Development has been completed and the contract for production of the new gauges should be awarded by October 1987. The NGWLMS takes advantage of an acoustic sensor to measure the water surface instead of conventional float and bubbler methods with their inherent non-linearity, aliasing and biasing problems. The acoustic sensor coupled with the development of new geodetic techniques based on the Global Positioning System and Very Long Baseline Interferometry has created the opportunity to link the motion between the sea surface and land.

Water level data will be stored on a Data Collection Platform (DCP) which will also accommodate additional sensors. These may include a backup water level sensor, air temperature, water temperature, water density, conductivity, current speed, current direction, wind speed, wind direction, barometric pressure and rainfall. Up to 11 sensors may operate through the NGWLMS DCP. Communication between the DCP and the Rockville, Maryland facility, will be through the GOES satellite with telephone as a backup. The system will also allow line-of-sight radio communication for local applications such as dredging operations or support of hydrography.

Under the continuing direction of Mr. Richard Hagemeyer as the National Weather Service Tsunami Program Manager and Director of the Pacific Region, a coordination conference was held in Seattle, Washington, in June 1986 to review operation of the Pacific Tsunami

Warning Center and the Alaska Tsunami Warning Center and to critique the Center's operation in response to the 7 May 1986 Aleutian earthquake. The change in message formats was one of the results of this critique. A program for the exchange of personnel between the 2 centers has been initiated with the Senior Electronics Technician from the PTWC visiting the ATWC for a 2-week period in July 1987. A similar visit to PTWC by ATWC staff will occur by the end of 1987, with a yearly interchange planned thereafter.

III. CENTER OPERATIONS

PACIFIC TSUNAMI WARNING CENTER (PTWC)

Seismic Data Acquisition and Alarm Activation

PTWC continues to receive real-time seismic data from 14 stations located on the continent of North America in addition to 9 seismic stations in the Hawaiian Islands. The North American network consists of stations extending from the Eastern coast of the United States to the Western Aleutian, with data telemetered to PTWC via a dedicated circuit from the National Earthquake information Center of the US Geological Survey. These stations provide PTWC with real-time data for a rapid preliminary epicenter determination for any earthquake in the Pacific Basin.

A solid state alarm system has been configured for selected seismic stations to provide an earlier response by PTWC. The concept used requires exceeding the signal threshold at 2 separate stations before alarm activation occurs to minimize alarm activation by strictly local earthquakes. Three such solid state 2-station alarm systems are now utilized by PTWC, with one on the island of Hawaii to provide an earlier response for local Hawaiian earthquakes, one on the continental United States to provide earlier alarm activation for earthquakes in North and South America, and the third in the Western Aleutian to provide an earlier response for earthquakes in Alaska and the Northwest Pacific. PTWC now is alerted to earthquakes in Chile within 12 minutes of origin and earthquakes in Kamchatka within 4 minutes of origin. As an example of the benefits gained by this 2-station seismic alarm system, PTWC personnel were alerted within 6 minutes of the origin of the Mexico earthquake of 19 September 1985 and as a result had determined the epicenter within 16 minutes of origin.

Earthquake Evaluation

PTWC has made significant improvement in 2 areas relating to evaluation of the location and size of an earthquake. The first has been in the development of improved computer software for epicenter determination for teleseismic events. Utilizing the multiuser, multitasking environment of the Data General S/230 minicomputer at PTWC, new input/output techniques have been implemented to upgrade the used friendly capability of the software. Initialization of an assumed epicenter is no longer required as the software now solves for all possible solutions on a world-wide basis and accepts as a final epicenter the best possible solution without operator intervention. At the same time, the new software provides information to the watchstander on the expected arrival times of several seismic phases at various strategic stations, including the S-phase and surface wave arrivals at Honolulu. The focal depth is computed and magnitude determinations can rapidly be determined at all stations for which real-time long period seismic data are available. The software continually prompts the watchstander for timely message dissemination based on the elapsed time since earthquake origin, with queries to seismic observatories for additional data being included in the software. The epicenter location relative to 2 major cities is also displayed to provide a relative geographical location. All of the above can be accomplished in less than 15 seconds and in the process automates many skills normally required of an experienced seismologist.

The second area of operational improvement relates to the determination of earthquake size. Based on the probability of tsunamigenesis as determined by historical events, the earthquake size as measured by seismic surface waves on the Richter scale provides the basic operational criteria for issuance of a Tsunami Watch by PTWC. The present threshold used is a magnitude 7.5 for an earthquake anywhere in the Pacific Basin, except for the Aleutian where the threshold is a magnitude 7.0 for issuance of a Watch. When available the size determination issued by PTWC is based on a comparison of magnitudes as measured at several stations and coordinated with the National Earthquake Information Center. In may instances, the timeliness of response requires that PTWC act on the size determination of only a single station, that of Honolulu. In an effort to evaluate the accuracy of PTWC's earthquake size determination, PTWC has completed a study of long period seismograms from Honolulu for the years 1978 through 1986. This included an evaluation of body wave magnitudes as well as surface wave magnitudes. The results indicate that the body wave magnitude as determined from the long period S-phase provides as reliable a measure of earthquake size as the seismic surface waves used for the Richter scale. The earlier arrival of the S-phase, as much as 25 minutes for Chilean events, renders it a valuable parameter to PTWC not only

for an earlier, and frequently more accurate, size determination, but also for an internal verification of the Richter size determination from Honolulu station. A paper documenting the results of this study is being prepared for publication in a suitable professional journal.

Tsunami Data Acquisition

At the time of ITSU-X, the United States reported on an initial effort at establishing a satellite sea level network with 7 Data Collection Platforms (DCPs) having being installed in the field. This network has been expanded to presently include 27 stations in South America and the Southwest Pacific, with sea level data transmitted automatically via the Geostationary Operational Environmental Satellite (GOES).

The distribution of these stations presently consists of 5 DCP's in Chile, 2 in Peru, 2 in Ecuador, one in Mexico,one in French Polynesia, 2 in the Cook Islands, one in New Caledonia, 3 in Kiribati, one in Tuvalu, one in the Solomon Islands, one in Papua-New Guinea, 2 in the Federated States of Micronesia, one in Nauru, one in the Marshall Islands, and one each at Johnston Island, Wake Island and Midway. Final arrangements are currently being worked out between the Center Polynesien de Prevention des Tsunamis and the PTWC for the installation of a DCP at the head of the Tonga-Kermadie Trench. The United States wishes to express its greatest appreciation to all countries involved for their support and active contributions, without which this data acquisition effort would not have been possible. Special recognition is also extended to Dr. Klaus Wyrtki of the University of Hawaii and Dr. David Enfield of the Oregon State University who provided funding and personnel for many of the field installations. As a result, not only has the Tsunami Warning System of the Pacific been provided with a network of automated sea level stations providing data by satellite to PTWC for a greatly improved Tsunami evaluation capability but these same stations are also providing sea level data for a variety of other purposes. One is also providing routine meteorological data.

Tsunami Evaluation

PTWC is conducting various applied research efforts in an attempt to develop a predictive tsunami evaluation capability throughout the Pacific Basin. Analyses of the historical earthquake and tsunami data on an area-by-area basis are providing information for an evaluation of the probable tsunamigenic threshold for the issuance of a Tsunami Watch or a Tsunami Warning. At the same time, these historical data constitute a critical parameter for the real-time evaluation of a Tsunamigenic event.

In other areas of applied research, PTWC has developed the operational software to compute tsunami travel times on a near real-time basis rather than be restricted to previous efforts of determining Estimated Times of Arrival (ETAs) from a pre-computed set of tables. The minimal spanning tree algorithm which has been used for a number of years to compute tsunami travel time estimates has been adapted to run on an IBM-PC desktop microcomputer. This program provides ETAs to all grid locations in a user specified list of stations for the Pacific Basin. On an operational basis, PTWC is using this newly developed software to compute ETAs for GOES DCP tide gauge stations for which travel time charts do not presently exist. This provides an improved capability during an actual event for determining the anticipated availability of sea level data being transmitted via GOES from remote locations. An auxiliary program provides a chart of travel time isochrones which can be printed on any printer to provide a graphical presentation of tsunami propagation across the entire Pacific Basin. Evaluation and refinement of this set of travel time software are continuing with the intention of making it available to all ICG/ITSU participants who desire an internal capability for direct computation of tsunami travel times to meet their own applications.

A third area of applied research at PTWC for tsunami evaluation has been the development of a preliminary version of an automatic data processing techniques in the form of infinite impulse response digital filters to eliminate both the tide signal and high frequency noise from the digital marigraphic data. The band pass signal is then rectified and its amplitude continuously compared to the output of a running average filter which provides a threshold level automatically adjusted to background noise. When the rectified output exceeds the threshold, a tsunami has been detected. The future operational application of this technique is twofold:

1. To continuously process sea level data transmitted to PTWC in real-time or near real-time from stations in Hawaii or via GOES from remote stations throughout the Pacific; and

2. To incorporate the algorithm as an integral component of a GOES DCP to provide a sophisticated tsunami event detector capability at all automated GOES DCP sea level stations.

Evaluation of this algorithm has been most promising, based on application of actual data transmitted via GOES from DCPs for the Adak Tsunami of 7 May 1986 and the Antofagasta Tsunami of 5 March 1987. The accompanying graphics for Easter Island and Caldera illustrate not

only the quality of data transmitted by GOES DCP's but also the capability of the tsunami detection algorithm to detect even small tsunami amplitudes in a high signal-to-noise environment such as Easter Island.

Communications

PTWC has completed the Eleventh Edition of the Communications Plan for the Tsunami Warning System, which has been completely restructured and updated as compared with earlier editions. Where previously seismological stations, tide stations and dissemination agencies were grouped separately, the new document has restructured all communications on a country-by-country basis. This not only provides flexibility for organization and arrangement of the Communications Plan, but also permits easier issuance of frequent updates as needed.

Computer Automation

In addition to the implementation of new operational software on the Data General minicomputer for teleseismic earthquake evaluation and for generation of Bulletins using the revised text and format, software is also being developed using 2 IBM-PC compatible microcomputers to perform supplemental tasks not available on the Data General. These include the software for computing tsunami travel times and for automatic tsunami event detection in real-time. In addition, the microcomputers are being used for many applications relating to the automated DCP sea level data acquisition program. Computer generated graphics of sea level data at remote DCP stations, such as illustrated in the previous graphics for Easter Island and Caldera, provide PTWC with a previously unavailable tsunami evaluation capability. One microcomputer has been interfaced to the National Meteorological Center to relay GOES DCP data automatically to PTWC for storage and processing by the IBM PC and software has been developed to automatically generate computer graphics for selected DCP stations. The microcomputers have also provided the primary capability for development of improved epicenter software for local earthquakes and for analyses of historical earthquake and tsunami events on an area-by-area basis. In summary, relatively inexpensive desktop microcomputers have been found to have numerous applications to PTWC's operations, with software development continuing in the areas of historical data studies, modeling and filtering techniques, computer graphics and computer-to-computer communications.

PTWC has also initiated a preliminary evaluation of modern minicomputers for future replacement of the aging Data General S/230 system presently being used. Computer procurement is anticipated within the next 2 years to provide PTWC with a computer capability capable of meeting continually expanding operational requirements for the next decade.

International Coordination

PTWC has continued with active participation in the IOC/ITIC Visiting Experts' Program. In 1985, Dr. Clemente Ropain of Colombia and Mr. Kim Ki Young of the Republic of Korea worked at PTWC in developing improved communications and operational procedures with their respective countries. In 1986, Mr. Sergio Hernandez of Guatemala and Ltk. Sofyan Rawi of Indonesia were selected as Visiting Experts and participated in the Program.

In 1985, as part of the NOAA/PRC Protocol on Cooperation in the Field of Marine and Fishery Science and Technology, Mr. Yang Huating and Mr. Zhou Qinghai of the National Marine Environmental Forecasting Center of the People's Republic of China visited the Pacific Tsunami Warning Center. In 1987, as part of the exchange of scientists, Mr. Richard Sillcox of PTWC and Dr. Walter Dudley of the University of Hawaii visited tsunami research institutions in China. The Pacific Tsunami Warning Center has also continued to work with Dr. Zhou of the PRC in association with his tsunami research at the Hawaii Institute of Geophysics.

In 1986, the PTWC staff prepared a revised draft for submission to IOC of the manual on "Wave Reporting Procedures for Tide Observers in the Tsunami Warning System."

In 1986, as part of a Project GEOSCOPE, scientists of the Institut National des Sciences de l'Univers (INSU) of Paris, France, completed installation in Hawaii of long period, broadband seismological instrumentation. In addition to geophysical research applications, the data provide an improved future capability for PTWC to quantitatively evaluate the tsunamigenic potential of an earthquake on a real-time basis. Dr. J. Talandier of the Center Polynesien de Prevention des Tsunamis (CPPT) has operationally implemented this capability for French Polynesia and is providing earthquake size evaluation to PTWC via teletype message for all major earthquakes in the Pacific Basin.

ALASKA TSUNAMI WARNING CENTER

ATWC Operations

The primary mission of the ATWC is to provide tsunami watches and warnings for Alaska, California, Oregon, Washington and British Columbia in Canada, for potentially tsunamigenic earthquakes (events) that occur in those regions. Since the last meeting, the ATWC issued 3 warnings with appropriate watches to Alaska, Canada

and the US West Coast. Two of the warnings were issued for earthquakes that occurred in the Andrean of Islands, Alaska, on 7 and 17 May 1986; and one warning for an earthquake that occurred on 27 February 1987 in the Fox Islands, Alaska. The 7 May event generated a 175cm tsunami at Adka and smaller ones elsewhere.

For non-tsunamigenic events or ones outside of the ATWCs areas of responsibility, event parameters and other associated information are appropriately disseminated to: the Alaska Division of Emergency Services; the Alaska Air Command; the National Earthquake Information Center; the Pacific Tsunami Warning Center; the USGS-Menlo Park Research Center; the Japan Meteorological Agency, Tokyo; the Royal Observatory, Hong Kong; the news media and to many other recipients including both State and Federal disaster preparedness agencies and military bases and appropriate agencies in Canada. Although many non-tsunamigenic earthquakes are automatically collected and processed each day at the ATWC, only about 15-20 events per month are released to officials and the public due to requests and/or operational procedures.

In addition to the primary mission, the ATWC personnel continue to process, archive and disseminate collected data; participate in fulfilling interagency cooperative agreements and conduct technique and equipment developments to improve the present system. The improvements involve both the reactive and predictive areas of the ATWC operational system. The reactive part concerns the reduction of response time between the occurrence of a tsunamigenic event and the issuance of a tsunami warning to people in the affected areas. In particular, this part seeks improvements in procedure modifications; present scientific methods used and development of advanced methods; advanced equipment and instruments; present and new software development and/or modifications and personnel performance. The predictive part involves both in-house and cooperative work efforts with other experts and/or agencies concerning areas such as tsunamigenic earthquakes and zones, tsunami data bases, formation and interaction with coastal zones.

During the Mt. Augustine volcanic explosions and subsequent eruptions in March and April of 1986, the ATWC was on constant alert in case a tsunami warning was necessary for the inhabitants in and about Mt. Augustine. This was a coordinated effort among 3 different agencies, namely - the ATWC, the Alaska Department of Emergency Services and the US Geological Survey's volcanological experts. No tsunami was generated from this hazard.

Seismic and Tide Data Acquisition

The ATWC continues to record about 80 real-time seismic traces that are telemetered to the Center via satellite from remote sites that are located in the Aleutian Islands, throughout Alaska, Hawaii and the lower 48 States. This accumulation of the data comes from 5 US agency's networks, namely - the ATWC, the USCS Research Center at Menlo Park, CA; the National Earthquake Information Center at Golden, CO; the University of Alaska at Fairbanks and the PTWC in Hawaii. Raw seismic data are collected and automatically processed to obtain event parameters and for information dissemination to the appropriate disaster agencies and other hazard centers.

The ATWC has access to 13 tide sites that range from Shemya, in the far western Aleutians, through Southern California. Tide data transmitted via satellite from 8 coastal Alaskan sites, are recorded in real-time at the ATWC for immediate confirmation of the existence or non-existence of a tsunami. Tide data are obtained from the west coasts of the US and Canada via teletypewriter and telephone and upon request by the ATWC. Since the late ITSU meeting, the ATWC has implemented a microcomputer system which enables the ATWC to access near real-time data from the National Ocean Survey's water level telemetry system (WLTS) which are located along the US West Coast. This access uses a computer-to-computer linking for transmitting selected windows of time periods of tide/tsunami data to the ATWC computer which are stored on disk for graphing, analysis, etc., and information dissemination.

Instrumentation

Equipment maintenance, additions, calibrations and developments are continuing functions at the ATWC's Center and field sites. At the Center, the incoming data are recorded on 24 helicorders, 6 develocorders, 16-track magnetic tape units and in a minicomputer system. The equipment and systems are monitored daily by personnel and electronic equipment, to ensure a continuous data flow to the Center. Selected seismic data continue to be added to the ATWCs archived develocorder data base which has been accumulating since 1967. Preventive maintenance, calibrations and parts replacements are performed for all remote seismic and tide sites and major equipment systems in the Center. All field sites are visited yearly or as soon as possible after equipment failure.

The major new equipment that has been installed at the ATWC include an automatic uninterruptable power system (UPS), an IBM AT microcomputer system and a micro real-time computer system (RT). The IBM AT was integrated into the operations in 1986 and the UPS and RT installed in 1987.

Communications and Warning Exercises

The ATWC continues to conduct many daily and monthly communication tests to monitor the dissemination and reception of tsunami information. These tests are conducted via teletypewriter, the National Warning System, the Alaska Warning System and a VHF radio. The results of these tests are used to detect problem areas that need immediate correction or improvement. The ATWC continues to maintain a list of critical telephone numbers that are frequently checked to ensure validity. Communication problem areas are corrected as they surface.

The ATWC has participated in a simulated warning exercise ("GOLDFISH") with officials from the State of Alaska Civil Defense, the Federal Emergency Management Agency, disaster authorities in Canada and other US Federal and State disaster agencies. For the exercise, a scenario was provided which included an assumed earthquake in the Shumagin Islands area, water wave travel times, ETAs and damage and wave heights.

Computers and Automation

The ATWC continues to use the automated DGS 230 minicomputer system to automatically detect and process earthquake data and to generate earthquake and tsunami information for dissemination. This system has been functioning for many years and was used during 2 of the past 3 warnings for processing and disseminating critical information to various TWS recipients, hazard officials, media, etc. However, it is nearly obsolete and problem prone and was inoperative during the 7 May 1986 Aleutian earthquake and subsequent tsunami. This system has been functioning 24 hours per day for many years, except during the time of maintenance and repair.

In addition to implementing a microcomputer for accessing tide data in near real-time for US West Coast tide sites, a microcomputer has also been integrated into the ATWC operations which functions as an interactive backup system to the present aging minicomputer system. This computer system is connected directly to a video display terminal (teletype system) for rapid dissemination of critical information. It was used during the 7 May warning when the minicomputer system was inoperative. It is not a real-time data acquisition system. Since it was first implemented, it has proved to be an invaluable operational system.

Due to the obsolescence of the minicomputer and the successful implementation of an interactive micro system, the ATWC was given the task of developing methods, software, etc., for a microcomputer system that would replace the present minicomputer system at the ATWC. The required concept and initiative studies for procuring a real-time microcomputer system were completed and the system installed at the ATWC during 1987. Work has begun to replace the present mini with a micro system.

Community Preparedness

The ATWC continues to provide a community preparedness program which includes visits to distant outlying coastal communities from Unalaska through Southern California and other local group facilities and schools that are within commuting distance of the ATWC. For the far Western Aleutians, the ATWC cooperates with and/or assists hazard officials who are responsible for community preparedness in those areas. In addition to the outside visitations and presentations, the ATWC facilities are opened to the public each Friday from 1 to 3 in the afternoon for local and other visitors. The earthquake/tsunami presentations in this program include items, such as a slide show concerning earthquake/tsunami effects; discussions concerning earthquakes and tsunamis; a community's particular hazard potential and their expected response and the ATWC operations and missions.

During the past 2 years, the ATWC staff visited more than 15 communities in and about the Sumagin Is., Unalaska, Kodiak, Yakutat, Juneau, Sitka and in the State of California.

Approximately 30 presentations were given to groups that are within driving distance of the ATWC facilities and more than 500 visitors toured the Center in Palmer.

Two Soviet scientists, Academician Anatoly S. Alekseev and Dr. Viacheslav K. Gusiakov, visited the Alaska Regional Headquarters in Anchorage and the Alaska Tsunami Warning Center (ATWC) in Palmer, during the period of 29 April to 8 May 1987. Academician Alekseev is the Director of the computer center institute at Novosibirsk, USSR Academy of Sciences, Siberian Division. Dr. Gusiakov is Chief of the Tsunami Program at the computer center. They were quartered in Palmer until 6 May and then in Anchorage for the remaining days.

The purpose of their visit to the ATWC was for indoctrination concerning the ATWCs: software and methods using mini- and microcomputer systems for automatically and interactively determining local, regional and worldwide earthquakes parameters in real-time and online; seismic tide real-time telemetry systems and the present operations and future developments of an automated regional tsunami warning system.

IV. RESEARCH ACTIVITIES

For the past 2 years, the US tsunami research community has been active in planning, conducting and communicating research on a tsunami. The largest sponsor of research was the National Science Foundation who funded the completion of 3 projects, all of which focus on 6 pro-

jects and the beginning of 2 new projects, all of which focus on the run-up problem along the coastline. In September 1985, NSF funded a workshop to identify the most critical research needs and to define an approach to meet these needs. Recommendations from this workshop included:

1. The commencement of a tsunami observational program to obtain quantitative information to verify coastal numerical models;

2 The formation of an integrated program of basic research in the engineering aspects of a tsunami; and

3. The creation of a Tsunami Advisory Panel to guide the direction of research.

In response to the NSF workshop recommendations, the National Oceanic and Atmospheric Administration (NOAA) began a deep water tsunami observational project off the Alaskan coastline in August 1986. In January 1987, this observational program was augmented by the Army Corps of Engineers, Coastal Research Program to include 7 shallow water (15 m) gauges along the west coast of the United States and Hawaii. Cooperation between these 2 research groups has resulted in the creation of a high quality research observational program for deep and shallow water.

Since 1983, the Agency for International Development (AID) has supported the design, development and evaluation of a low-cost tsunami warning system capable of delivering tsunami information within 15 minutes of tsunami generation. The satellite linked, early Tsunami Warning System was installed in September 1986, in Valparaiso, Chile, to evaluate its value in mitigating tsunami hazards in countries without local warning systems. The system is composed of a pre-tsunami preparedness program and real-time data collection and information dissemination equipment. To develop the preparedness program, an examination of historical data supplemented by numerical model simulations of potential tsunamis provided the basis for evacuation areas in Valparaiso's emergency operational plan. The instruments used to collect geophysical data include an accelerometer to measure earthquake intensity and a pressure gauge to measure tsunami activity. A major earthquake activates the entire system by triggering the threshold level of the accelerometer/transmitter which sends a message to the NOAA/GOES satellite that a major earthquake has occurred. The computer controlling this satellite immediately responds to the earthquake message by simultaneously broadcasting an alert message to the Chilean Tsunami Warning Center in Valparaiso, to the pressure gauge in the harbour and to the Pacific Tsunami Warning Center in Honolulu, Hawaii. Each receiver responds to the alert message in a predetermined way relative to its role in the system. Within minutes (2-minute average) of the earthquake, the pressure gauge transmits wave information, the Chilean Tsunami Warning Center and the Pacific Tsunami Warning Center issue tsunami alerts and monitor the pressure gauge for tsunami activity. Since installation of the system, over 25 alert exercises have been conducted and over 8,000 test messages have been transmitted through the satellite system with over 99 percent reliability. The equipment has operated with 97 percent reliability for the past 9 months. The project will conclude evaluation tests in September 1987 when final reports will be written and distributed.

The US Geological Survey has funded a one-year numerical modeling study of the tsunami hazard associated with the potential of a large earthquake off the coast of Washington and Oregon. The Army Corps of Engineers completed a study of the tsunami flood levels in Alaska for the Federal Emergency Management Agency in 1987. The 100-and 500-year combined tsunami and tide elevations were predicted for the southern coast of Alaska using historical data supplemented by numerical model simulations.

One of the more important activities that was completed in 1986 was the creation of a tsunami data base at NOAA's National Geophysical Data Center. This data base consists of 1,600 tsunamis since 49 B.C. and more than 3,800 locations where tsunamis were recorded or observed. These data are digitally stored on a user friendly computer system that allows search and statistical capabilities. For example, calculations of the distance from the epicenter to the locations of fatalities show that over 97 percent of all fatalities associated with tsunami occurs within 400 km of the epicenter.

US scientists have been active in communicating tsunami research results by participating in special tsunami sessions of PACON '86 and the Fall 1986 meeting of the American Geophysical Union. Over 25 articles on tsunami were written and published in the scientific literature during the past 2 years.

V. INTERNATIONAL TSUNAMI INFORMATION CENTER (ITIC)

The United States, recognizing the importance of the International Tsunami Information Center to the Pacific Tsunami Warning System and to ITSU, has continued to provide support in the period since ITSU-IX at a stable level. Presently, the United States pays the salaries of the ITIC Director and the Secretary. In addition, the United

States provides the logistical support that enables ITIC to fulfill its mandate. Thus, the United States is continuing its support which enables ITIC to perform most of its basic functions, but continues to look also to the international community for additional support that will enable ITIC to fulfill more adequately its mandate. (Full details on the ITIC activities are provided in the Director's Report).

THE NATIONAL REPORT OF THE UNION OF SOVIET SOCIALIST REPUBLICS

I. INTRODUCTION

From the beginning of the mid-1950's, the Interbranch Tsunami Warning Service has been in operation in the Soviet Union. Its duties include the permanent observation on the seismic situation in the Pacific region, timely registration of strong underwater earthquakes, the estimate of their intensity and tsunami activity and observations for tsunami developments with the help of hydrophysical equipment. On the basis of all this information, the population and different organizations of the coastal regions of the Far-East are provided by Tsunami Warnings.

II. STRUCTURE OF THE NATIONAL TSUNAMI WARNING SERVICE

Several ministries of the USSR take part in activities of the Tsunami Warning Service. The Academy of Sciences of the USSR provides seismic aspects of this work. The USSR State Committee for Hydrometeorology and Control of Natural Environment provides registration of sea level changes at Far-Eastern coastal points, while passing and arranging Tsunami Warnings to corresponding organizations and local authorities. Communication channels of the USSR Ministry of Communications are used for operational transmission of tsunami reports.

Three seismic stations, situated in this district, in Petropavlovsk-Kamchatsky, Yuzno-Sakhalinsk and Kurilsk are involved in direct duties of operation the Tsunami Warning Service. Besides, the seismic stations Severo-Kurilsk and Vladivostok, partly carry out such functions.

With the threat of a tsunami, sea level changes control is organized in 9 coastal points: Petropavlovsk-Kamchatsky, Oust-Kamchatsk, Bering Island, Severo-Kurilsk, Matua Island, Urup Island, Kurilsk, Yuzno-Kurilsk and Nakhodka.

Three independent centers, situated in Petropavlovsk-Kamchatsky, Yuzno-Sakhalinsk and Vladivostok, carry out collection and analysis of the information from seismic and tidal stations, estimation of tsunami risk, the possibility and areas of possible tsunami spreading, calculation of tsunami arrival time to the shore and tsunami warnings to the population and organizations of the Far-Eastern coastal areas.

The existence of these 3 independent centers was caused by considerable extent of the USSR tsunami dangerous shore and peculiarities of the Far-Eastern Administrative Division.

III. TASKS OF THE NATIONAL TSUNAMI WARNING SERVICE

The work of the National Tsunami Warning Service is based on the following principles:

- Providing timely registration of underwater earthquakes and strong underwater volcanic eruptions, the estimation of tsunami spreading possibility, whcih could be dangerous, calculation of areas to be affected and calculation of tsunami travel time and, after all, providing warnings and notification about a tsunami threat in good time;

- Organization of the timely evacuation of people and properties out of areas in which tsunami effects are expected (such as removal of ships out of harbors and ports);

- Instructions to people about their actions in case of a tsunami warning declaration and instruction of tsunami knowledge among the population;

- Providing long-term measures, connected with planning and gradual realization of actions, which are aimed in the transfer of objects out of tsunami dangerous areas.

IV. CRITERIA USED IN THE WORK OF THE NATIONAL TSUNAMI WARNING SERVICE

The seIsmic method of short-term tsunami prognosis is based on the existence of a significant difference between the velocity of a seismic earthquake wave spreading in the earth's crust snd the velocity of the tsunami spreading, formed as the result of this earthquake.

The potential of a tsunami formation as a result of an underater earthquake is determined by the magnitude-geographical criteria. If there is an earthquake registered with above some critical value (for various areas critical areas of magnitude are adopted to be different) and with the coordinates of the epicenter situated in a tsunamigenic area defined beforehand, in this case it would be considered tsunamigenic.

The hydrophysical means of measures, placed on tidal stations, play an auxiliary role in tsunami warnings at present, fixing facts of presence or absence of tsunami effects on the coast. Only in individual cases with tsunami spreading along the coastline, short-term hydrophysical methods of tsunami prediction is important.

V. DEVELOPMENT OF THE NATIONAL TSUNAMI WARNING SERVICE

In the last few years, long-period seismographs are being included at seismic stations. These seismographs provide earthquake registration in a broad range of periods and output of information on the equipment of visible record and on automatic equipment for the interpretation of seismic signals. Such equipment allows increasing essentially the accuracy and reliability of tsunami prediction by the seismic method.

For the development of short-term tsunami prediction by the hydrophysical method, investigation on the possibility of using different types of sea level offshore registration equipment is taking place.

Also, improvement in the software in the Tsunami Warning centers are being carried out.

A complex investigation is carried out in the research on a tsunami generation, spreading in the ocean, behaviour at the shelf and at the shore and on tsunami regionalization.

VI. INTERNATIONAL EXCHANGE OF INFORMATION ON STRONG UNDERWATER EARTHQUAKES AND TSUNAMIS

The communication channel of the Global Telecommunication System of the World Meteorological Organization Khabarovsk-Tokyo is used for providing international exchange on the strong underwater earthquakes and tsunamis between the USSR and other Member States in the Pacific. The transmission of information between Khabarovsk and the Soviet Tsunami Warning Centers is being carried out with the help of the USSR internal communication links.

During the intersessional period, operational exchange of information about tsunamigenic earthquakes and tsunami warnings continued. The Soviet Union took part in tsunami tests issued by the Pacific Tsunami Warning Center.

VII. TSUNAMI EVENTS

Significant tsunami events have not been observed at the USSR coasts during the period of August 1985 (the time of the last Tenth Session of the International Coordination Group for the Tsunami Warning System in the Pacific) to February 1987.

The interesting event was the Pacific-wide tsunami, caused by the earthquake on 7 May 1986 in the region of the Aleutian Islands and being registered at the Aleutian Islands, in Hawaii and at the Pacific coast of Japan. During this event, tsunamis at the Kamchatka peninsula and the Kuril Islands had not been observed. As the detailed investigation of this event shows, tsunami effects were marked only in isolated points in the middle part of the Kuril Islands, in particular the level of increase on Matua Island while the tsunami passing reached aobut 15 centimeters.

REPORT FOR TSUNAMI DATA ACTIVITY, WORLD DATA CENTER-A FOR SOLID EARTH GEOPHYSICS

The World Data Center-A (WDC-A) for the Solid Earth Geophysics is operated by the US Department of Commerce as part of the National Geophysical Data Center (WDC-A) of the National Oceanic and Atmospheric Administration. It has a major role in the data collection including the compilation, cataloguing and synthesis of all available information on tsunami sources and effects to support modeling, planning and education purposes.

A major effort of this data collection is the development of a digital tsunami data base consisting of information on the source (location, cause, validity and magnitude) and effects (location of effects, wave heights, damage and number of deaths). The initial event list was prepared by Doak Cox during a Sabbatical at the World Data Center in an effort to revise and update the Preliminary Catalogue of Tsunamis Occurring in the Pacific Ocean by Iida, Cox and Pararas-Carayannis. Additional information was added from the World Data center files for earthquakes, epicenters, magnitudes and depths. Tsunami effects including wave heights, damage and numbers of deaths were added from several sources including the Catalogues of Tsunamis of the Eastern Coasts of the Pacific Ocean by Soloviev and Go.

Currently, the Pacific data base consists of about 1,600 events since 49 BC, (including all validities), and more than 3,800 locations where tsunamis were recorded or observed. Recent additions include: 1,000 actual travel times, 386 arrival times and more than 1,000 place names and run-ups. Data acquired from Japan supplied 1,000

run-up locations in that country. The Alaska Tsunami Warning Center supplied 1,000 coordinates for run-up locations. The data base has been checked by researchers in Japan (Dr. Ichikawa) and Chile (Dr. Lorca). The tsunami data are useful in the preparation of tsunami maps and lists of tsunami having certain characteristics such as location, wave height, damage and effects.

The digital file allows for a number of statistical questions to be examined. For example, calculations of the distance from the epicenter to the location of fatalities when given shows that over 97 percent of the fatalities occur within 400 km of the epicenter.

A data base has also been compiled for events occurring outside the Pacific Basin in the Mediterranean and Caribbean Seas and the Atlantic Ocean. There are 389 events in this file and 228 locations where these tsunami were recorded or observed. The file has information on 60 destructive events. This data is being reviewed by Alan Ruffman of Geomarine Associates in Nova Scotia who has done research on tsunamis generated on the western shores of the Atlantic.

A wall-size multicolor map depicting the Pacific Basin tsunamis (1900-83) has been published using the WDC-A digital data base. The map shows the location of 405 events (including earthquakes, volcanic eruptions and landslides) that caused tsunamis. Tables list dates of the events, event parameters, number of deaths and destruction. An initial free distribution of the map was made to cooperating scientists, key emergency and civil defense offices and International Tsunami organizations including members of the International Oceanographic Commission, International Coordination Group for the Tsunami Warning System in the Pacific (IGC/ITSU) and members of the Tsunami Commission of the International Union of Geodesy and Geophysics (IUGG).

In addition to the digital tsunami data, NGDC/WDC-A continues to acquire marigrams (tide gauge records showing evidence of a tsunami) and tsunami photographs. Interesting recent acquisitions include:

* a set of digitized marigrams for 33 Chile stations events;

* 28 digitized records of 5 major tsunami events recorded at US stations in the Pacific;

* a set of 35 marigrams for the May 1983 tsunami in Japan;

* 6 marigrams from Hawaii stations that recorded the March 1985 Chilean tsunami;

* 76 marigrams from the National Weather Service;

* 33 marigrams from the 7 August 1984, 19 September 1985 and 3 March 1985 event from the Japan Meteorological Agency;

* 8 marigrams from the 7 May 1985 event from the International Tsunami Information Center; and

* 20 marigrams from the 7 May 1986 event from the Pacific tsunami Warning Center.

Bathymetric data and seismograms of tsunamigenic earthquakes continue to be available.

As part of the THRUST project, WDC-A produced a publication entitled "Tsunamis Peru-Chile" by P. Lockridge, 1985, that examines historical tsunamis and earthquake data for 6 coastal regions in Peru-Chile. Each of the regions includes tabular information on tremors that generated tsunamis, damage and deaths caused by tsunamis, maps that show extent of coastline affected by several large tsunami and areas throughout the Pacific that have reported tsunamis generated near Peru and Chile.

A publication entitled "US Tsunamis" is currently being prepared. This publication will include some information on tsunamis themselves, problems inherent in the compilation of a historical data base, a description and listing of tsunamis generated and/or occurring in Hawaii, Alaska and the West Coast of the United States and an analysis of the tsunami risk in each area.

Future projects include a continual refining and supplementing of data now in the data files. Information on source dimensions, as inferred from earthquake aftershocks and information on focal mechanisms will also be added to the file over the next several years. NGDC is also currently cooperating with the Japanese in the development of a tsunami propagation model. The Japanese are adapting their tsunami travel time computing programs to NGDCs digital bathymetry for the Pacific and will give NGDC the completed program in exchange.

ANNOUNCEMENTS

BIRMINGHAM POLYTECHNIC OFFERS COURSE IN DISASTER MITIGATION

Birmingham Polytechnic in England will be running a 44-week course beginning in January 1988. The course places disaster mitigation planning firmly into a developmental context and it is devoted to the limitation of the vulnerability of natural and technological disaster on people, the environment, technological installations and physical infra-structure. Hence, this will be most relevant to participants from countries experiencing earthquakes, volcanic eruptions, tropical cyclones, floods and famine. For more information please write to:

Course Secretary,
City of Birmingham Polytechnic,
Birmingham School of Architecture,
Faculty of the Built Environment,
Perry Barr, Birmingham B42 2SU, United Kingdom

PACIFIC TELECOMMUNICATIONS COUNCIL TENTH ANNUAL CONFERENCE, FEBRUARY 15-18, 1988

The Pacific Telecommunications Council's 10th annual forum entitled "Telecommunications and Pacific Development: Alternatives for the Next Decade", will be held in Honolulu on February 15-18, 1988. It is expected that 600 participants will be attending from 30 countries, from Asia, the Americas and the Pacific. PTC '88 will seek to organize sessions based on communication needs, Telecom demands, Government Regulation and competition affecting the Telecom/Info. Market, by examining past accomplishments and changes, current facilities and services and future trends, requirements and issues. For more information please write to:

PTC '88,
Pacific Telecommunications Council,
1110 University Avenue, Suite 308
Honolulu, Hawaii 96826 USA.

EUROPEAN GEOPHYSICAL SOCIETY XIII GENERAL ASSEMBLY, 21–25 MARCH 1988

The European Geophysical Society will hold its thirteenth General Assembly on 21-25 March 1988, at the University of Bologna, Italy. The University of Bologna is celebrating its 900th year anniversary. It is the oldest university in the world. A meeting on tsunamis and related phenomena is being planned for 22-23 March in conjunction with this conference. The tentative title of the meeting is: "Tsunamis Generated by Earthquakes and Volcanic Eruptions: Theory and Observations." Convenors of the tsunami meeting are Professors Tinti, Soloviev, and Adams. Please send your proposed title and abstract to one of these convenors as soon as possible.

Professor Stefano Tinti,
Department di Fisica,
Settore di Geofisica,
Universita'degli Studi de Bologna,
Viale Berti Pichat,8,
Bologna, Italy 40127.

Dr. S.L. Soloviev,
Chief, Department of Geophysics,
Institute of Oceanology,
Krasikova 23,
Moscow 117218,
USSR.

Professor W.M. Manfield Adams,
HIG 410-A,
University of Hawaii,
Honolulu, HI 96822,
USA.

The University of Bologna was the first university in the world. To participate in this conference and anniversary celebration will be a great and memorable experience.

PACON'88

The third Pacific Congress of Marine Science and Technology (PACON'88), will be held in Honolulu, Hawaii, May 16-20, 1988, and promises to be of wide interest to the marine community. This major Congress will focus on some of the new developments in marine technology that will vastly alter the way we think about and use the ocean. Technological trends and opportunities will be addressed from a multidisciplinary perspective, making PACON of major interest to planners, policy makers, and administrators as well as to scientists, and engineers. The conference will be divided into two major areas:

1.) Ocean Sciences and Technology, (to discuss new technological developments); and

2.) Marine Resources Management, (to discuss the intricacies of wisely developing the great variety of resources available to the Pacific). Seventeen technical sessions will be held during the five days of the Congress, with specific topics including, among many, Ocean Energy, Marine Mining, Remote Sensing, Tsunamis and Ocean Robotics. In addition, four workshops will be held on the final day dedicated to general discussion, and new products and developments will be exhibited throughout the Congress.

The Conference Committee invites papers for presentation at the Congress. Full length papers will be due November 30, 1987. Please send title, and abstract (about 400 words), as soon as possible to:

PACON'88, c/o
SEA GRANT COLLEGE PROGRAM,
UNIVERSITY OF HAWAII,
HONOLULU, HAWAII 96822.

KAGOSHIMA INTERNATIONAL CONFERENCE ON VOLCANOES, 1988

The Kagoshima International Conference on Volcanoes will be held in Kagoshima, Japan in July 1988. The general theme of the conference will be "Towards Better Coexistence Between Human Beings and Volcanoes." It is hoped that the conference will help to deepen the understanding of volcanoes and to exchange views on the mitigation of volcanic hazards and utilization of volcanic resources across national borders, with the aim being to exchange information and promote research. All correspondence regarding the conference should be addressed to: International Affairs Division, General Affairs Department, Kagoshima Prefectural Government, 14-50 Yamashita-Cho, Kagoshima City, 892, Japan.

INTERNATIONAL CONFERENCE ON NATURAL AND MAN-MADE HAZARDS IN COASTAL ZONES, AUGUST 14-21, 1988, ENSENADA, MEXICO

The International Conference on Natural and Man-Made Hazards in Coastal Zones will be held at San Diego, California (Scripps Institute of Oceanography) and at CICESE (Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, B.C.), Ensenada, Mexico, on August 14-21, 1988. This is the third biannual Conference to be held. The 1986 Conference in Quebec and Rimouski, Canada, was very successful and attracted prominent people in disaster management and mitigation from all over the world. It is expected that the Conference in Ensenada will be equally successful. A second circular has been prepared and details of the Conference Program are being finalized. The program will include topics on all man-made and natural hazards affecting the worlds coastal zones, including earthquakes, tsunamis, volcanic eruptions, surges, erosion and engineering problems, wind storms, landslides, pollution, etc. A special session will be held on risk management and insurance, the legal aspects of hazards, and on plans and proposals for the International Decade of Natural Hazard Reduction. The third International Conference on Natural and Man-Made Hazards is being sponsored by many national and international organizations, among them: the Tsunami Society, the International Tsunami Information Center, IOC, and CICESE.

Please submit abstracts of papers as soon as possible to:

Dr. George Pararas-Carayannis,
Chairman, International Organizing Committee,
International Conference on Natural and Man-Made Hazards in the Coastal Zones,
c/o ITIC,
P.O. Box 50027, Honolulu, Hi 96850, USA.

JOINT OCEANOGRAPHY ASSEMBLY, MEXICO, AUGUST 23-31, 1988

The Joint Oceanographic Assembly will take place at the Acapulco Convention Center, Acapulco, Mexico, from Ausgust 23 to 31, 1988. A second announcement has been circulated inviting marine scientists thorughout the world to indicate their interest in the assembly and participate. The Conference will consist of General Symposia of invited papers on selected topics of broad interdisciplinary subjects, and Associated Sessions of contributed papers and posters.

The General Symposia will include new developments in ocean and climate investigations, and special symposia in the oceanography of Mexico. All correspondence regarding papers and registration should be addressed to:

M. en C. Roberto Gutierrez Galera,
Executive Secretary,
JOA, Mexico 1988,
c/o Direccion Ajunta de Asuntos,
Internacionales CONACYT,
Apartado Postal 20033,
04515 Mexico, D F,
Mexico.

EMNHD, BANGKOK 1987

The US-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD), was held on December 14-18, 1987, in Bangkok, Thailand. It was organized by the University of Hawaii, and the Asian Institute of Technology, with cooperation of the US. National Science Foundation.

The purpose of the conference was primarily to provide an open forum for intensive discussions to identify problems of mutual interest, and to propose possible cooperative projects concerning this field of professional practice. The program will include a keynote speech, special lectures and papers covering current practice and research on winds, earthquakes, floods, and ground failures, followed by panel and group discussions to formulate plans for cooperative research. Also, a field trip was held.

OFFSHORE TECHNOLOGY CONFERENCE (OTC), May 2-5, 1988

The 20th OTC will take place on May 2-5 1988, at Houston, Texas. For two decades the OTC has led the worldwide dissemination of new technology related to ocean resource development and environmental protection. For more information please write to:

Program Department,
Offshore Technology Conference,
P.O. Box 833868, Richardson TX 750, 83-3868.

TSUNAMI BOOK

Walt Dudley, Professor at University of Hawaii-Hilo, has collaborated with Min Lee to produce 'Tsunami!'. The book is being published this fall; the reviews say it is hard to put down.

NEW JOURNAL ON NATURAL HAZARDS

The D. Reidel Publishing Company has announced that in the Spring of 1988, they will commence publication of "Natural Hazards", an international journal of hazard research and prevention. Editors are:

M.I. Ei-Sahh, University of Quebec.
G. Schneider, University of Stuttgart.
Y. Fujinaiwa, National Research Center for Disaster Prevention, Japan.

Manuscripts should be written in English and submit-

ted in triplicate to:

Natural Hazards,
The Journals Office,
D. Reidel Publishing Company,
P.O. Box 17,
3300 A A Dordrecht,

The Netherlands. The journal will publish papers on atmospheric, hydrologic, oceanographic, volcanologic, seismic, and neotectonic hazards, and will also consider papers on man-made technological hazards. Papers may address analytical and statistical techniques, and case studies. Occasional state-of-the-art reviews will be welcomed.

SPANISH TRANSLATION OF MASTER PLAN

Capitan Ricardo Alvarado Reyes, who succeeded Capitan Ernesto Cajiao Gomez as Secretary General of the Colombian Commission of Oceanography, has provided ITIC with a translation of the Master Plan on the Tsunami Warning System, prepared by Mr. G. Dohler of Canada.

This translation will greatly facilitate the use of this document by the Spanish-speaking members of the International Coordination Group for the Tsunami Warning system in the Pacific (ICG/ITSU).

Dr. George Pararas-Carayannis, Director of ITIC, wrote Capitan Alvarado on behalf of IOC and members of ICG/ITSU thanking him and the Colombian Commission of Oceanography for their inititiative in carrying out this important task.

For copies of the Spanish translation of the Master Plan, write directly to:

Capitan de Fragata Ricardo Alvarado Reyes
Secretario General
Comision Colobiana de Oceanografia
Calle 41, No 46-20 4o. Piso - Can
Bogota, Colombia

SYMPOSIUM PROCEEDINGS AVAILABLE

Proceedings of the Symposium on Natural and Man-made Hazards are now available at $149 per copy. Orders should be sent to:

D. Reidel Publishing Company,
Kluwer Academic Publishers,
Order Department,
P.O Box 358,
Accord Station, Hingham, MA 02018-0358
USA.

INTERNATIONAL CONFERENCE ON EEZ RESOURCES: TECHNOLOGY ASSESSMENT, JANUARY 11-13, 1989, HAWAII, USA

The Conference will address techniques available or required for the initial reconnaissance assessment of resources and conditions (including physical, biological, geological, meteorological, environmental, and oceanographic) within EEZs, as a necessary prerequisite to evaluation and exploitation, to enable the characterization, measurement and monitoring of the impact of future activities. Papers are invited in the following areas: Definition of EEZ conditions prior to intervention. Available assessment technologies. Monitoring deficiencies. Case studies.

Single-page abstracts should be sent by December 15, 1987 to:

Paul C. Yuen,
University of Hawaii,
College of Engineering,
2540 Dole Street,
Honolulu, Hawaii 96822,
USA.

Authors will be notified by January 31, 1988 of the

acceptance of the abstracts as well as the deadline to submit full papers. The Conference is sponsored by the U.S. National Science Foundation and the Society for Underwater Technology and is coordinated by the International Ocean Technology Congress.

The International Ocean Technology Congress (IOTC) is an organization of people who are actively involved in ocean technology. The Congress encourages international membership since the ocean activities of one country can affect the ocean environment of neighboring countries. The Congress has three main purposes: to provide an international forum for countries to inform each other of planned ocean activities and policies; to create a supportive environment in which ocean projects requiring multi-nation cooperation and/or funding can be proposed; and to advocate the development of ocean resources in an environmentally-acceptable manner.

PACIFIC TSUNAMI WARNING CENTER

Seismic Summary

(May 6 to Press Time)

EVENT NO.	EVENT	LOCATION	ACTION TAKEN
1987-11	May 06 0406Z 6.5	Andreanof Islands 50.2N 179.3W	Earthquake Information Bulletin issued
1987-12	May 07 0306Z 6.5	Eastern USSR northeast of Vladivostok 46.8N 139.1E	No Earthquake Information Bulletin issued
1987-13	Jun 17 0133Z 6.5	Banda Sea, Indonesia 05.5S 130.6E	Earthquake Information Bulletin issued
1987-14	Jul 06 0106Z 6.5	Easter Island, Chile 26.3S 107.9W	No Earthquake Information Bulletin issued
1987-15	Jul 06 0250Z 6.7	Banks Island, Vanuatu 13.8S 167.7E	Earthquake Information Bulletin issued
1987-16	Aug 08 1549Z 6.8	Arica, Chile 18.2S 069.9W	Earthquake Information Bulletin issued
1987-17	Sep 03 0640Z 7.0	Macquarie Ridge, south of New Zealand 58.2S 158.5E	Earthquake Information Bulletin issued
1987-18	Sep 03 0802Z 6.5	Macquarie Ridge 60.9S 153.9E	No Earthquake Information Bulletin issued
1987-19	Sep 22 1344Z 6.6	Colombia/Ecuador border 00.8S 077.0W	Earthquake Information Bulletin issued

1987-20	Sep 28 1147Z 6.9	Erromangosland, Vanuatu 18.9S 168.0E	Earthquake Information Bulletin issued
1987-21	Sep 28 1349Z 6.5	Erromango Island, Vanuatu 22.6S 171.6E	No Earthquake Information Bulletin issued
1987-22	Oct 06 0419Z 7.0	250 miles south of Apia, Western Samoa 17.3S 172.0W	Earthquake Information Bulletin issued
1987-23	Oct 12 1357Z 7.0	Solomon Islands area 06.7S 154.4E	Earthquake Information Bulletin issued
1987-24	Oct 16 2048Z 7.7	South of New Britain, Papua-New Guinea 06.3S 148.5E	Earthquake Investigation and Earthquake Information Bulletin issued
1987-25	Oct 25 1654Z 6.8	North coast of the Island of New Guinea 01.8S 138.6E	Earthquake Information Bulletin issued
1987-26	Nov 17 0847Z 6.8	Northern Gulf of Alaska 59.0N 143.2W	Earthquake Information Bulletin issued
1987-27	Nov 30 1923Z 7.4	Cape Yakataga, Alaska 52.9N 142.2W	Regional Tsunami Watch issued